POWER

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FRED R. LOW, *Editor*

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The Conqueror

THOMAS ALVA EDISON.

The world paused for an hour to take account of the man and to appraise its indebtedness to him.

What has the usual object of popular interest and demonstration done to improve the condition and outlook of those who acclaim him?

One has broken a record. Another has espoused a popular cause. Another has repelled an invader, pushed back the boundaries of the empire or seated a new ruler.

All of which leaves the individual citizen much as he was before, except that the glory of the military hero has been won at the cost of thousands of blighted lives, desolated homes and years of widespread cost and privation.

What have the achievements of all the outstanding figures of man's continual combat with his fellowmen done to advance the well-being of the average citizen?

What, as compared with the accomplishments of those scientists, inventors and engineers who, with no less courage, perseverence, and devotion, have wrested her secrets from Nature, conquered famine, disease and pestilence, annihilated space and time, shifted the burden of the daily grind from human muscle to swift and tireless machinery, and multiplied the comforts, conveniences and cultural facilities of the masses?

The man who has led his country out of a perilous situation stands out glorified and conspicuous in the public eye. The man who has devoted years of patient endeavor to mitigating the severities of man's eternal struggle with his environment is often never known by name to hosts of his beneficiaries.

A great industry has fittingly fêted its founder. Let there be still more laurels for the winners of the Victories of Peace.

F. R. Low

POWER *Stands for . . .*

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**

What Should the Manufacturer Sell?

IN these days of extreme competition it is not unusual that many voices should be lifted in discussing ways and means of securing one's share of whatever business is offered.

While some are doing the lifting, a few are showing the way. These have succeeded in establishing their businesses on footings that have given them something to sell besides mere products of so much iron and steel.

One has found a way to deliver his contracts earlier than others, and so reduce the capital cost that later completion would involve. People prefer to deal with such a concern, and are actually able to pay something more for this company's services, since it saves expense elsewhere.

Other companies offer to accept payment for their goods from the savings their equipment will accomplish in service. Here again there is something more for sale than the mere factory product.

The idea does not apply exclusively to the machinery manufacturers by any means, for a prominent banker said it was exactly what he was trying to accomplish for his institution.

So, whatever the mission, it will pay the power industry to give thought to this untrod ground in planning the location of its batteries for the next big offensive.

Where Efficient Units Cut Marginal Losses

THERE is a tendency to overlook the importance of efficient steam prime movers in industrial plants where most of the exhaust steam is utilized. As long as any exhaust is wasted for considerable periods, the obtainable fuel savings will justify a substantial investment to increase the steam economy of the generating units. In some cases, in fact, the fuel saving will be as great as in a plant where none of the exhaust could be utilized.

To see just what this may mean, let us analyze an extreme and simplified case. Assume a non-condensing plant with a constant electrical load of 1,000 kw., a constant process-steam load of 27,000 pounds per hour, a boiler evaporation of nine pounds per pound of coal, and a fuel cost of $5 per ton. If, under such conditions, the steam rate of the prime movers is cut from thirty-six pounds per kilowatt-hour to twenty-seven pounds, the actual saving in steam to be generated will be 9,000 pounds per hour, exactly the same as if no exhaust whatever could be utilized. With the assumed 100 per cent load factor, this amounts to $21,900 yearly in fuel alone. On a twenty per cent basis this would justify an additional expenditure of approximately $100,000, or $100 per kilowatt installed. For each pound reduction of steam rate in such a plant (down to the limit of twenty-seven pounds) an additional investment of $10,000 would be justified.

Where steam and power loads vary, the saving and justified investment would be less, but still large in typical cases. Study of daily load curves for various seasons will make possible a close estimate of the pounds of waste steam saved yearly by any given reduction in engine steam rate. From this the fuel saving can easily be computed.

In most cases where new installations are under consideration it will be found worth while to pay the price of the more efficient unit if it will substantially reduce the waste of exhaust steam. A considerably larger saving will, of course, be needed to justify replacing an old engine or turbine in good operating condition by a new and more efficient unit, but even this will prove economical in cases where large amounts of exhaust steam are wasted over a considerable portion of the year.

A Call for Building-Load Curves

THE advisability of byproduct power generation in large buildings—office buildings, hospitals, department stores, theaters, etc.—depends largely on what is loosely termed "heat balance." More precisely, it depends on the percentage of the total power consumed that must (if no power is bought) be generated from steam not usable for heating or process.

In public buildings condensing operation for this portion of the power load is generally impracticable. Diesel engines, it is true, offer a means of generating this load with low fuel cost, and the matter of combining Diesel engines with steam prime movers well deserves the attention it is beginning to receive.

Leaving the Diesel for discussion elsewhere, it is easily figured that power generated by efficient steam prime movers, operating at customary throttle pressures and exhausting to atmosphere, will require at least three pounds of coal per kilowatt-hour. This is more than six times the fuel consumption chargeable to byproduct power. It is, therefore, clear than the fuel cost—and the total cost—of the average kilowatt-hour generated by steam in public buildings will depend very largely on the

amount and duration of such excess power demands. Because of this, the conclusion to buy or generate power, and (if the latter) the selection of the plant to be installed, cannot be intelligently made without reliable curves predicting the steam and power consumption of the building hour by hour for typical days in the four seasons. With such curves in hand the working out of the best combination is largely a matter of simple arithmetic.

Careful study of load curves in connection with cost and efficiency figures for various types of units will show clearly how far it is worthwhile to go in reducing excess exhaust steam by higher steam pressures, electrified auxiliaries, heat storage and by shifting the periods of certain controllable steam and power demands.

Without this analysis, design and operation are mere guesswork, unworthy of the name of engineering. It is an important function of a power publication to promote such studies constantly, but something more than mere exhortation is necessary. Actual curves of power and steam consumption in various types of buildings must be made available to designers and operators. *Power* readers in building plants equipped with recording instruments can assist the editors in this important task by submitting load curves for their plants with such data (for example, cubical contents of buildings) as will make possible their reduction to a unit basis applicable for estimating purposes to other buildings of the same type.

Perishable Water Power

NOW and then somebody rises to remark that the water powers of his state or nation should be preserved for its residents. Proposals to develop power sites to supply an outside market are cried down or forbidden by law, on the ground that the development should be delayed until the power is needed at home.

This assumes that the power will keep until it is needed, and to deny this appears at first sight absurd. Physically it is true that a water power site is good until used, for geographical and climatic conditions do not ordinarily change rapidly. But what about the economic aspect of the matter? There are water power developments that were made ten or fifteen years ago and have paid a comfortable return on the investment, which could not be justified to-day, if their development had been delayed. Improvements in the steam plant have so altered the balance that a study based on starting fresh would indicate for many a situation that the steam plant or the Diesel plant will pay a higher return on the investment than the water power.

General rules are few, but among them is the observation that the most permanent thing in the world is change. In the field of power engineering this is particularly true. The technical and economic scenes are constantly shifting. The exponents of keeping power sources for home consumption would do well to reflect that perhaps they are holding a perishable commodity. Capable of a profitable development now, their sites may in ten years be overshadowed by new possibilities in other fields. Meanwhile, by waiting, the dogs in the manger have foregone the chance of ten years of profitable operation. The past is surely gone forever, and the future may evaporate. The present should be free from unreasonable barriers of sentiment or law, free for the exercise of technical and economic intelligence.

Why Delay Power Plant Improvements?

IT MUST at times become discouraging to the power engineer who, knowing the large savings possible by investing even a moderate sum in new plant equipment, always receives from the management the reply that funds are not available for such work. When this condition really exists it constitutes a legitimate reason for not complying with suggested improvements; and against it the engineer has no argument.

Observations, however, made during a recent editorial trip lead to the belief that many times this is merely an excuse, and the old adage where "there's a will there's a way" holds true in this case as elsewhere.

In one of the plants visited, the management had for many years pleaded poverty to the engineer's frequent requests for power house improvements. But one day the boiler inspector announced that unless drastic action were taken, he would reduce the steam pressure allowed in the boilers. This action by the boiler inspector constituted a threat against the normal manufacturing operations, and opened the eyes of the management to the necessity of spending money in the power house.

From some mysterious source, capital was secured, thus giving the engineer an opportunity to do the work he had long ago suggested. Perhaps to the surprise of the management—certainly to the gratification of the engineer—the decrease in power and heatings costs was sufficient to return the capital expenditures in a reasonable time. This illustration is typical.

That changes in the power plant were not made sooner may have been due to the inability of the engineer to properly "sell" his ideas to these superiors, or it may also have been because of stubbornness on the part of the management. Whatever the cause, imagine the savings that would have been made if the management had placed greater faith in the engineer's judgment and improved the power house when he first suggested it.

Although central-station performance has been steadily improved until a kilowatt-hour on a pound of coal is now an accomplished fact, the one great waste has been the heat going out in the condensing water. A new type of central station is now making its appearance, designed to serve to an industrial community both electricity and steam for process. The plant of the Southeastern Production Company at Mobile, described in this number of *Power*, typifies this idea—an idea that should be applicable to many other communities.

POWER and PROCESS S

Supplied From Central Station to

By WM. G. ALLEN
Southern Engineering Company

THE MOST ECONOMICAL METHOD *of using high-pressure steam calls for power and process heat from a common source. It is unusual to have both of these commodities supplied from a central station, and so the plant here described is of particular significance. The initial installation is a 6,000-kw., 450-lb. turbine arranged for extraction at 150 and 35 lb. and exhausting at 5 lb. back pressure, and a 2,000-kw. condensing unit. Process steam is supplied to a paper mill at the two extraction pressures. The paper machines are turbine-driven by 150-lb. steam, and their exhaust is used for drying.*

AT MOBILE, ALA., the Southeastern Production Company has designed and built a central station to furnish power and process steam to the new paper mill of the International Paper Company, located about 700 ft. from the power house. While this power plant is relatively small, it is important and it represents the faith of the power company in the growing industrial possibilities of this district. Mobile is equipped with modern shipping and port facilities and is near the Panama Canal, leading by ocean transit to all the markets of the Far East. Around this new plant are expected to grow up chemical industries; artificial ice plants; artificial fertilizer plants, using Florida phosphate rock shipped in by water; coal-processing plants and innumerable other industries.

Steam, after passing through the main turbine, will not be condensed, but will be extracted at intermediate points in the turbine for processes in the paper mill. In this way the heat energy, which would otherwise be lost in the circulating water of the condenser, is usefully employed in the various processes of making paper. The heat-balance, shown in Fig. 3, will enable the chief features of the design to be followed. The quantity of make-up water is large. This required sinking two wells from which a supply of reasonably pure water at a fairly uniform temperature could be obtained. Of the process steam taken by the paper mill, only 35 to 45 per cent is expected to be returned as mill condensate, accounting for the large amount of make-up water.

The well water is pumped by deep-well motor-driven pumps into an elevated steel storage tank, and the make-up water then passes through softening tanks. This water is then subjected to further treatment to maintain the correct degree of alkalinity. The make-up water passes into the hot-water condensate storage tank,

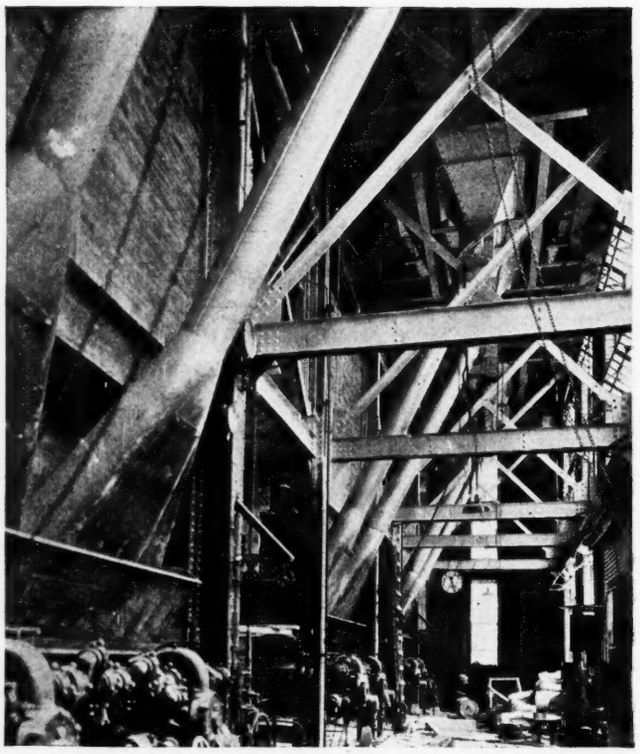


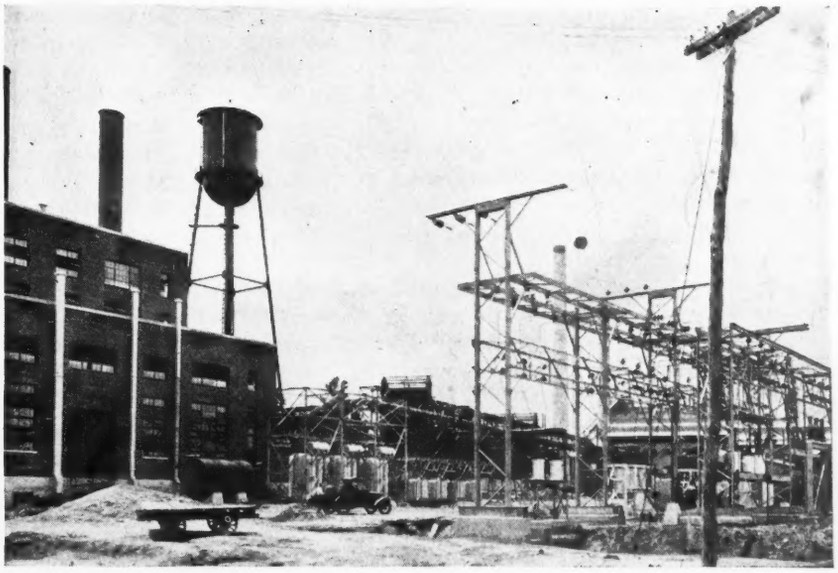
Fig. 1—Preheated air at 325 deg. F. is supplied to the stokers on each of the three 13,111 sq.ft. boilers

where it mixes with the hot mill-condensate returns and attains an average temperature from 98 to 113 deg. F.

Duplicate mill-condensate and make-up water pumps take the make-up water from the hot-water condensate storage tank and pass it into a deaërating open heater. Here the water is heated to about 215 deg. and deaërated.

Duplicate boiler-feed pumps, one steam-turbine-driven and the other motor-driven, take the hot make-up water from the open heater and force it into the boilers through a low-stage and a high-stage closed feed-water heater. These two closed heaters take steam from the two extraction points on the 6,000-kw. turbine driving the main generating unit. In this connection an interesting problem arose as to the best means of dealing with the condensate from these heaters. It was finally decided to discharge the heater condensate, by a single-stage centrifugal pump, into the boiler-feed pumps at a point between the first and second stages of the latter. At this point the pressure is sufficiently high to preclude the possibility of the condensate flashing into steam and binding the boiler-feed pumps. Ordinarily, the pressure in a five-stage pump designed for 550 lb. discharge pressure would be about 110 lb. between the first and second stages. The design of these boiler-feed pumps is such that the pressure between the first and second stages is about 70 lb., corresponding to a saturated-steam temperature of 316

STEAM to Paper Mill



On the left is the power house, which is connected to the paper mill, on the right, by a 14-in. 35-lb. and a 12-in. 150-lb. process-steam line, about 700 ft. long. These lines are carried overhead on structural-steel towers and open girder work

deg. As the heater-condensate temperature is about 281 deg., the arrangement obviates the possibility of the condensate flashing into steam in the pumps.

The feed water, leaving the deaërating open heater at about 215 deg. (equivalent to about 1 lb. per sq.in. gage), is mixed in the boiler-feed pumps with the condensate drained from the feed-water heaters. The temperature of water leaving these pumps is about 224 deg.

The two closed heaters, one low-stage and one high-stage, are supplied with steam at 35 and 150 lb. pressure, respectively, extracted from the main steam turbine, these being the pressures required for the process-steam pipe lines. In the low-stage heater the feed water is raised from 224 to 275 deg., approximately, while in the high-stage heater it is raised from 275 to 360 deg., approximately. These terminal temperatures of the outflowing feed water are based on a terminal temperature difference of 6 deg. between the steam and the water. This difference will vary with the power and process-steam loads, that is, with the quantity of feed water required for the boilers. Moreover, as the heating areas of the tubes in both heaters are arranged to be equal, the actual terminal temperature differences may vary somewhat from the theoretical. This is because the volume and velocity of feed-water flow through both heaters are identical. The thermal head between the steam and the inflowing water is about 85 deg. for the high-stage heater and only about 51 deg. for the low-stage heater.

Both the high- and low-stage heaters and the boiler-feed water header are designed and arranged to operate under 550-lb. pressure. This allows a maximum differential of 75 lb. between header pressure and boiler pressure.

There are three Stirling-type boilers, each having 13,111 sq.ft. of heating surface, rated to produce 90,000 lb. steam per hour, maximum, at 475 lb. gage. Normally, all three boilers will be operated at about two-thirds rating.

The boilers are fired with underfeed stokers equipped with link grate overfeed sections and double-roll clinker grinders. The stokers and clinker grinders are driven by steam turbines, which exhaust into the open heater. Hydraulic sluicing equipment handles the ashes.

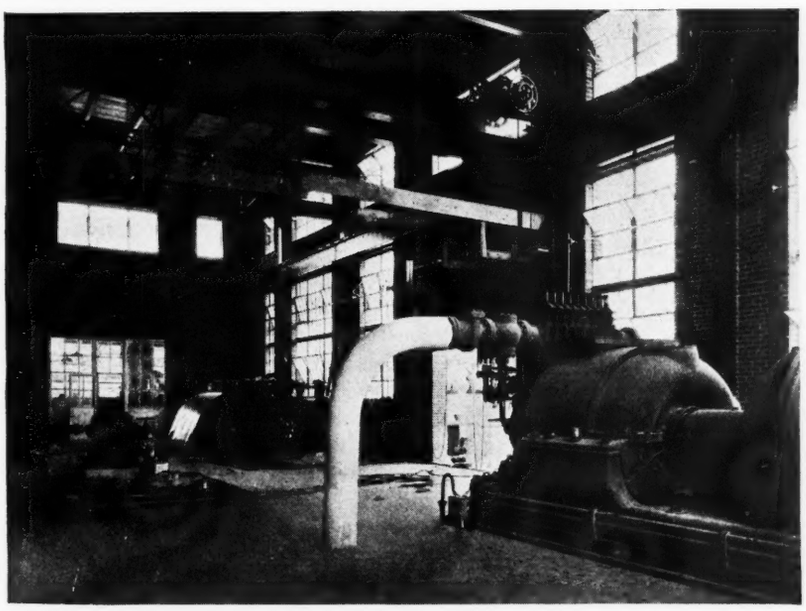


Fig. 2—In the turbine room there is a 6,000-kw. non-condensing and a 2,000-kw. condensing unit

Each boiler is provided with its own induced-draft and forced-draft fan mounted on the top floor of the boiler house. These fans are designed to operate at two speeds, obtained by a two-motor drive.

No economizers are installed, but air preheaters having a heating surface of 6,695 sq.ft. are provided. The air supplied to the underside of the stokers in the windbox will have a minimum temperature up to 325 deg. Each boiler discharges its flue gases into a short steel stack. Dampers are provided for ingoing air and outgoing flue gases, and automatic combustion control is installed. Boiler, superheater and air preheater performances are given in the equipment table.

There are two turbine-generators. One is rated at 6,000 kw., designed for double-extraction, non-condensing back-pressure

exhaust operation. The other is rated at 2,000 kw. and exhausts into a jet condenser. The large machine will run during normal operation and the small machine will be a stand-by and reserve unit. The power busbars, into which these machines feed, will supply power to the paper mill and will also be connected through transformers with the transmission system of the Alabama Power Company. Every precaution has been taken to prevent a complete interruption of the power or process-steam supply.

The extraction pressures arranged for on the 6,000-kw. turbine are 150 and 35 lb. per square inch gage, and the exhaust 5 lb. back pressure. The exhaust passes into the deaërating open heater, as does the exhaust from the auxiliary turbines when they are operating.

On the turbine the steam extraction outlets are connected to 12-in. and 14-in. pipe lines, which run to the paper mill, about 700 ft. away. These pipe lines can also supplying steam turbines driving the paper machines. This steam may be superheated not exceeding 100 deg., which is equivalent to a total steam temperature of about 466 deg. The balance of the steam extracted at 150 lb. may pass to the high-stage closed feed-water heater. Should the demand by the paper mill for process steam at this pressure reach the maximum of 85,000 lb. per hour, that available for feed-water heating in the high-stage heater might not exceed 15,000 to 20,000 lb. per hour. Under such conditions the final feed-water temperature would fall short of 360 deg.

After extracting 100,000 lb. per hour, the balance of the steam, 90,000 lb., passes to the second extraction point. Here any quantity of steam may be extracted up to the total. It is not expected that the demand for process steam at 35 lb. pressure will exceed 70,000 lb. per hour. It will probably average 60,000 lb. This will leave a balance for feed-water heating in the low-stage

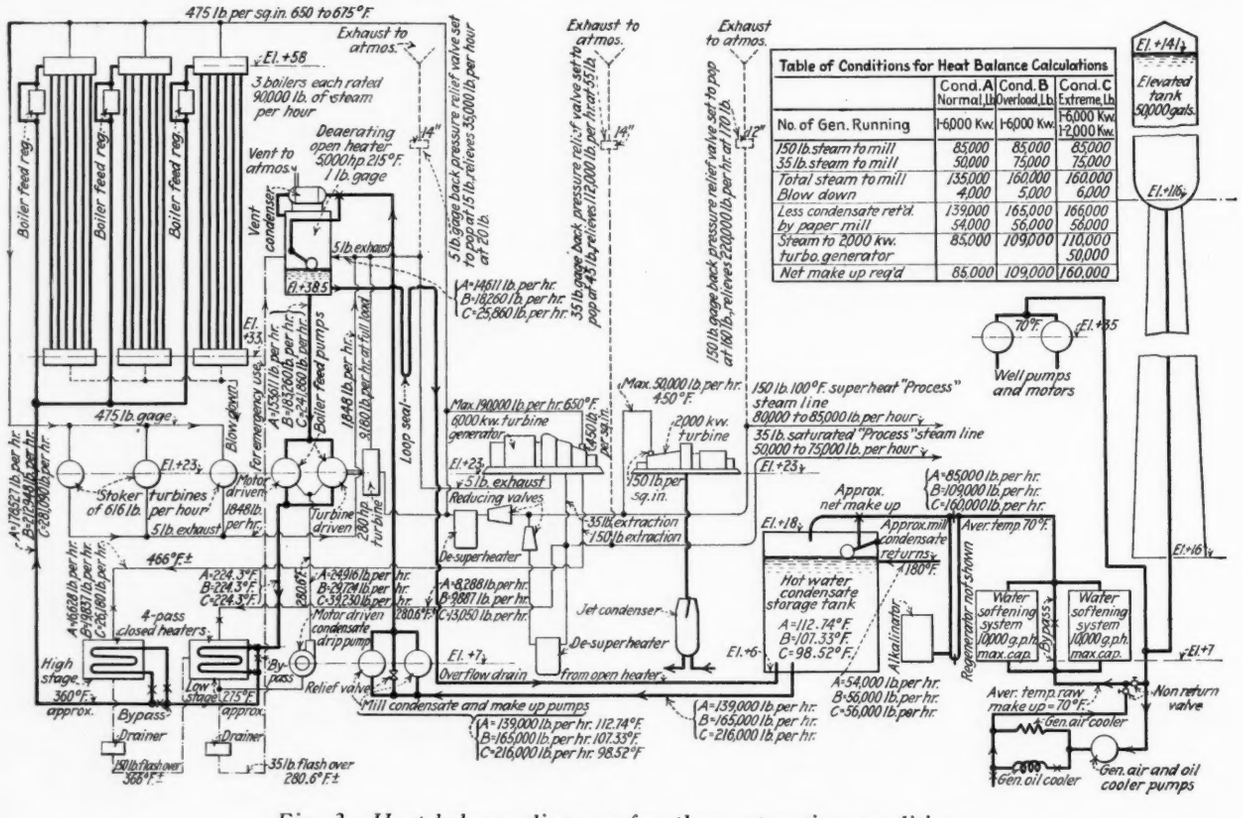

475 lb. per sq.in. 650 to 675°F
Exhaust to atmos.
El. +58
3 boilers each rated 90000 lb. of steam per hour
Deaerating open heater 5000 hp. 215°F. 1 lb. gage
Vent to atmos.
Vent condenser
Boiler feed reg.
Boiler feed reg.
Boiler feed reg.
5 lb. exhaust
5 lb. gage back pressure relief valve set to pop at 15 lb. relieves 35,000 lb. per hour at 20 lb.
35 lb. gage back pressure relief valve set to pop at 45 lb. relieves 112,000 lb. per hr. at 55 lb.
150 lb. gage back pressure relief valve set to pop at 180 lb., relieves 220,000 lb. per hr. at 170 lb.
Exhaust to atmos.
Exhaust to atmos.
Table of Conditions for Heat Balance Calculations
Cond. A Normal, Lb
Cond. B Overload, Lb
Cond. C Extreme, Lb
No. of Gen. Running
150 lb. steam to mill
35 lb. steam to mill
Total steam to mill
Blow down
Less condensate ret'd. by paper mill
Steam to 2000 kw. turbo. generator
Net make up req'd
Elevated tank 50,000 gals.
El. +141
El. +116
El. +85
El. +16
El. +7
El. +6
El. +18
El. +23
El. +33
El. +38.5
475 lb. gage
Stoker of 6/61 lb.
Motor driven
Turbine driven
Boiler feed pumps
Loop seal
Blow down
For emergency use
Well pumps and motors
70°F.
Max. 190000 lb. per hr. 650°F.
6000 kw. turbine generator
Max. 50,000 lb. per hr. 450°F.
2000 kw. turbine
150 lb. 100°F. superheat "Process" steam line
80000 to 85000 lb. per hour
35 lb. saturated "Process" steam line
50,000 to 75000 lb. per hour
150 lb. per sq.in.
35 lb. extraction
150 lb. extraction
Reducing valves
De-superheater
Approx. net make up
Approx. mill condensate returns
Hot water condensate storage tank
Aver. temp 70°F.
Regenerator not shown
Alkalinator
Water softening system 10000 g.p.h. max. cap.
Bypass
Aver. temp. raw make up = 70°F.
Non return valve
Gen. air cooler
Gen. oil cooler
Gen. air and oil cooler pumps
4-pass closed heaters
High stage
Low stage
By-pass
Relief valve
Jet condenser
Overflow drain
From open heater
Mill condensate and make up pumps
Bypass
Drainer
150 lb. flash over 368°F.±
35 lb. flash over 280.6°F.±
466°F.±
360°F. approx.
215°F. approx.

Fig. 3—Heat-balance diagram for three operating conditions

be supplied with steam from the boilers. Steam at boiler pressure and temperature can be desuperheated and passed through a pressure-reducing valve. The desuperheater is controlled by a thermostatic device operating on its water supply, and the reducing valve automatically maintains 150 lb. pressure in the process main.

In like manner, the 150-lb. steam can be further desuperheated and its pressure reduced by passing it through a second reducing valve and desuperheater, where it is brought down to approximately saturation temperature at 35 lb. and may, in emergencies, be fed to the low-pressure process-steam line.

The double-extraction turbine is designed to pass 190,000 lb. of steam per hour between the throttle and the 150-lb. extraction point, where up to 100,000 lb. per hour may be extracted. Of this quantity, from 80,000 to 85,000 lb. per hour can be delivered as process steam to the paper mill for use in heating digesters or for closed heater, and to pass through the remaining blading of the turbine to the exhaust and to the deaërating open heater. Steam flow and the pressures at the two extraction points and at the exhaust are automatically controlled by grid valves.

Steam entering the turbine at the throttle at 450 lb. and 675 deg. total temperature contains about 1,344 B.t.u. per pound. The heat-drop through the turbine under various conditions is shown in the table.

The total heat-entropy diagram consists of three sections: one corresponding to each of the three turbine sections. As the quantities of steam flowing through any section of the turbine may be different from, and may vary independently with, the quantities flowing through the other two sections, the power and other calculations have to take account of this and treat each section of the turbine separately.

As the demand for process steam and the demand for

Principal Equipment in the Plant of the Southeastern Production Company

Boilers, Superheaters and Air Preheaters

Manufacturer ..... Babcock & Wilcox Co.
Boilers, type ..... Stirling
Number 3
Heating surface, sq. ft., each 13,111
Maximum steam per hr. lb. each 90,000
Gage pressure, lb. 475
Total steam temperature deg. F. ..... 650 to 675
Air preheaters, type ..... Tubular
Heating surface, sq. ft. 6,695
Temperature of air to underside of stoker, deg. 325

Stokers and Clinker Grinders

Manufacturer ..... Westinghouse Elec. & Mfg. Co.
Stokers, type ..... Underfeed
Number of retorts each 8
Number of tuyeres each 33
Type of drive, steam-turbine, exhausting against 5 lb. back pressure and requiring 616 lb. of steam per hr.; clinker-grinder drive the same as that on the stokers.
Furnace water walls ..... Fuller-Lehigh Co.
Exposed water wall surface per boiler, sq.ft. 438
Soot blowers ..... Diamond Power Specialty Corp.
Boiler refractories ..... Harbison-Walker Refractories Co.
Boiler feed-water regulators ..... Swartwout Co.
Pressure, lb. 600
Excess pressure, lb. ..... 10 to 15

Combustion Control

Manufacturer ..... Hagan Corp.
The system consists of a master regulator to actuate three receiving regulators on the induced-draft dampers and three receiving regulators to control the stoker speed. There are also three regulators on the forced-draft dampers actuated by the combustion chamber pressure.

Induced- and Forced-Draft Fans

Manufacturer ..... B. F. Sturtevant Co.
Induced-draft fans, number 3
Number of speeds 2
Capacity, c.f.m. 75,000
Static pressure, in. of water 6
Temperature of gas, deg. 475
Speed, r.p.m. 700
Capacity, c.f.m. 48,000
Pressure, in. of water 3.5
Temperature of gas, deg. 406
Speed, r.p.m. 437
Each fan is driven by a 200-hp., 700-r.p.m. and a 60-hp., 437-r.p.m. 550-volt Westinghouse induction motor.
Forced-draft fans, number 3
Number of speeds 2
Capacity, c.f.m. 44,000
Static pressure, in. of water 15
Temperature, deg. 100
Speed, r.p.m. 870
Capacity, c.f.m 33,500
Pressure, in. of water 10
Speed, r.p.m. 695
Each fan is driven by a 200-hp., 870-r.p.m., and a 75-hp. 695-r.p.m. 550-volt Westinghouse induction motor.

PERFORMANCE OF BOILERS AND STOKERS
(Based on guarantees)

Evaporation Pounds Per Hour	Efficiency Per Cent	Cu.Ft. Air Per Min.	Windbox Static Pressure, In.	Max. Exit Gas Temp., Deg. F.	Min. Windbox Air Temp., Deg. F
30,000	85.4	10,330	0.7	515	275
45,000	84.0	14,500	1.3	550	295
60,000	84.0	18,600	2.0	585	310
75,000	83.5	23,000	2.7	620	310
90,000	82.2	27,900	3.7	655	325
107,000	79.4	34,000	5.2	700	330

PERFORMANCE OF BOILER PLANT AT TWO RATINGS
(Based on guarantees)

Pounds of steam per hour, actual	60,000	90,000
Drum safety-valve pressure lb., gauge	475	475
Superheated steam temperature, deg. F.	650	670
Per cent CO_2 leaving boiler	14	15
Per cent CO leaving boiler	0	0
Per cent C in dry refuse	8	15
Per cent loss due to soot	0	2
Temp. flue gas leaving boiler, deg.	570	640
Temp. flue gas leaving preheater, deg.	378	436
Temp. water entering boiler, deg.	361	361
Temp. air entering preheater, deg.	80	80
Temp. air leaving preheater, deg.	308	324
Eff. boiler, superheater and furnace, per cent	78.2	75.0
Eff., boiler, superheater, preheater and furnace, per cent	83.2	79.8
Draft loss through boiler, in. of water	0.20	0.50
Draft loss through air preheater, in. of water	0.42	0.85
Air resistance through preheater, in. of water	0.73	1.50
Pounds of flue gas per hour	74,400	106,500
Pounds of air through preheater, per hour	65,900	93,900

Coal analysis, per cent: Carbon, 70.05; hydrogen, 4.65; sulphur, 0.71; oxygen, 6.28; nitrogen, 1.62; moisture, 5.00; ash, 11.69; B.T.U. per lb. as fired, 12,500.

Coal-Handling Equipment

Manufacturer ..... Link Belt Co.
Capacity, tons per hr. 50
Consists of one apron conveyor and one elevator.
Motor on the apron conveyor, 5 hp.; on the elevator, 15 hp., Westinghouse.

Ash-Handling Equipment

Manufacturer ..... Allen-Sherman-Hoff Co.
Type ..... Hydrojet
Water supplied at 75 lb. per sq.in. by two 500-g.p.m. Cameron centrifugal pumps; and 125 lb. per sq.in. by one 1,000-g.p.m. Cameron centrifugal pump. The small pumps are driven 40-hp. 1,750-r.p.m., 550-volt induction motors and the large pump by a 125-hp., 550-volt induction motor.

Stacks

Manufacturer ..... Birmingham Tank Co.
Number 3
Type ..... steel
Height, ft. 30
Diameter, ft. 6

Desuperheaters and Open Heaters

Manufacturer ..... Elliott Co.
Desuperheaters 2
Type ..... Cartridge, automatic control
Open heater 1
Type ..... Deaerating
Capacity, 5,000 hp., 150,000 to 180,000 lb. per. hr.

Closed Heaters

Manufacturer ..... Griscom-Russell Co.
Number 2
Number of passes 4
Surface area, sq.ft. 726

Boiler-Feed Pumps

Manufacturer ..... Cameron—Ingersoll Rand Co.
Number 2
Capacity, g.p.m. 584
Total discharge head, ft. 1,324
Drive, one 280-hp. Westinghouse steam turbine; one 300-hp. motor.

Deep Wells and Pumps

Manufacturer of pumps ..... Layne & Bowler Inc.
Installed by ..... Layne Central Co.
Number 2
Pumps, capacity each, g.p.m. 500
Depth of wells, ft. 130
Pumps driven by 75-hp., 1,170 r.p.m. induction motors.

Condensate and Make-up Water Pumps

Manufacturer ..... Cameron—Ingersoll Rand Co.
Number 3
Size, two 420 g.p.m. against 83-ft. total head and one 94 g.p.m against 149 ft. total head. Drive, 15 hp. 550 volt induction motors.

Miscellaneous Equipment

Water purifying equipment, Wm. B. Scaife & Sons Co., consists of two Zeolite softening tanks, each of 10,000-gal. per hr. capacity, and one alkalinator.

Elevated water-storage tank, Chattanooga Boiler & Tank Co., 50,000-gal. capacity, with float switch for starting and stopping deep-well pumps.

Air compressor, Worthington Pump & Mach. Corp., one 5½x4½-in. vertical duplex type, driven by a 15-hp., 865-r.p.m induction motor.

Overhead traveling crane, Whiting Corp., hand-operated, 20-ton capacity, 32-ft. 6-in. span, 35-ft. lift.

Oil-filtering equipment, S. F. Bowser & Co.; 275 gal. per hr.; 1,000-gal. precipitation tank.

Piping ..... B. Floersheim & Co.
Pipe covering, 85 per cent magnesia ..... Johns-Manville, Inc.
Building structural steel ..... Ingalls Iron Works Co.

Meters

Boiler feed water, venturi ..... Builders Iron Foundry
Steam-flow meters ..... Republic Flow Meters Co.
Recording thermometers ..... Taylor Instrument Co.'s
Recording pressure gages ..... Taylor Instrument Co.'s
Indicating Thermometers ..... C. J. Tagliabue Mfg. Co.
Draft Gages ..... Ellison Draft Gauge Co.
Indicating pressure gages ..... Ashton Valve Co.

Valves

Relief and bypass ..... Grinnell Co.
Safety ..... Consolidated Ashcroft-Handcock Co.
Reducing ..... Fisher Governor Co.
Stop ..... Edward Valve & Mfg. Co.
Values in the steam and water lines supplied by Walworth Co.; Chapman Valve Mfg. Co.; Edward Valve & Mfg. Co.; Lunkenheimer Co.; and Crane Co.

Steam Turbines

Manufacturer ..... General Electric Co.
Number and capacity, one 6,000 kw. and one 2,000 kw. Steam condition at throttle, 450 lb. gage, 675 deg. total temperature. Steam extracted from 6,000-kw. unit at 150 lb. and 35 lb. gage pressure; exhausts at 5 lb. back pressure. The 2,000-kw. unit operates condensing, exhausting to a Westinghouse jet condenser.

PERFORMANCE OF 6,000-KW. TURBINE

Heat Drop Through Turbine	Steam Flow, Lb. per Hr.	Heat Drop B.t.u. per Lb.	Steam Flow, Lb. per Hr.	Heat Drop B.t.u. per Lb.	Steam Flow, Lb. per Hr.	Heat Drop B.t.u. per Lb.
From throttle to 150-lb. extraction	190,000	69.5	100,000	68	.....	.....
From 150-lb. to 35-lb. extraction	90,000	78	80,000	79.7	50,000	71.4
From 35-lb. extraction to 5 lb. exhaust	20,000	49.2	17,500	49.8	5,000	25.5

Generators, one 6,000- and one 2,000-kw., 13,300-volt 3-phase, 60-cycle ..... General Electric Co.
Generator air and oil coolers ..... General Electric Co.
Motor-generator set, 50 kw. for emergency excitation ..... Westinghouse Elec. & Mfg. Co.
Generator air oil cooler pump, 200 g.p.m. 110- to 135-ft. head ..... Cameron—Ingersoll-Rand Co.
Eleven power transformers main and auxiliary ..... Westinghouse Elec. & Mfg. Co.
Main switchboad and instrument transformers ..... Westinghouse Elec. & Mfg. Co.
Station service switchboard and field breaker panel with carbon circuit breakers ..... I. T. E. Circuit Breaker Co.
Oil circuit breakers, solenoid and motor operated ..... General Electric Co.
Storage battery ..... Electric Storage Battery Co.

power on the 6,000-kw. turbine may not coincide in their fluctuations, three back-pressure relief valves, exhausting to the atmosphere, are provided and connected, respectively, to the 150-lb. and the 35-lb. process- steam lines and to the 5-lb. exhaust line. Should the pressure rise in any of these lines, the corresponding relief valve will open and allow steam to blow to the atmosphere. These relief valves will act as safety devices to prevent damage to the steam turbine and its accessories.

The plant is equipped with instruments so that complete sets of observations and readings can be made during operation. At a point close to the paper mill there will be two sets of metering and recording instruments for measuring the quantity, pressure and temperature of the process steam supplied.

Another feature of the plant is a 6,000-sq.ft. boiler under which bark is burned. This plant, although owned by the Southeastern Production Company, is separate from the power plant and is between the latter and the paper mill. It is arranged to supply steam of the same quality as the 150-lb. process-steam supplied to the paper mill. The two process-steam lines are carried overhead on structural-steel towers and open girder work.

The power plant represents an investment of close to $1,500,000 and stands as a measure of the faith the Southeastern Power & Light Company and its subsidiaries have in the future development of Mobile and its environs. It is hoped that in the not distant future the demand for power will call for an enlargement of the plant to several times its initial capacity.

The plant was designed by the Southeastern Engineering Company and built by the Dixie Construction Company for the Southeastern Production Company, all of these companies being subsidiaries of the Southeastern Power & Light Company. William P. Hammond, as engineer for the Southeastern Engineering Company, was in direct charge of design work, with John M. Gallalee, of the University of Alabama, and A. T. Hutchins, of the Alabama Power Company, as consultants. All work on design and construction was under general direction of O. G. Thurlow, chief engineer of the Southeastern Power & Light system.

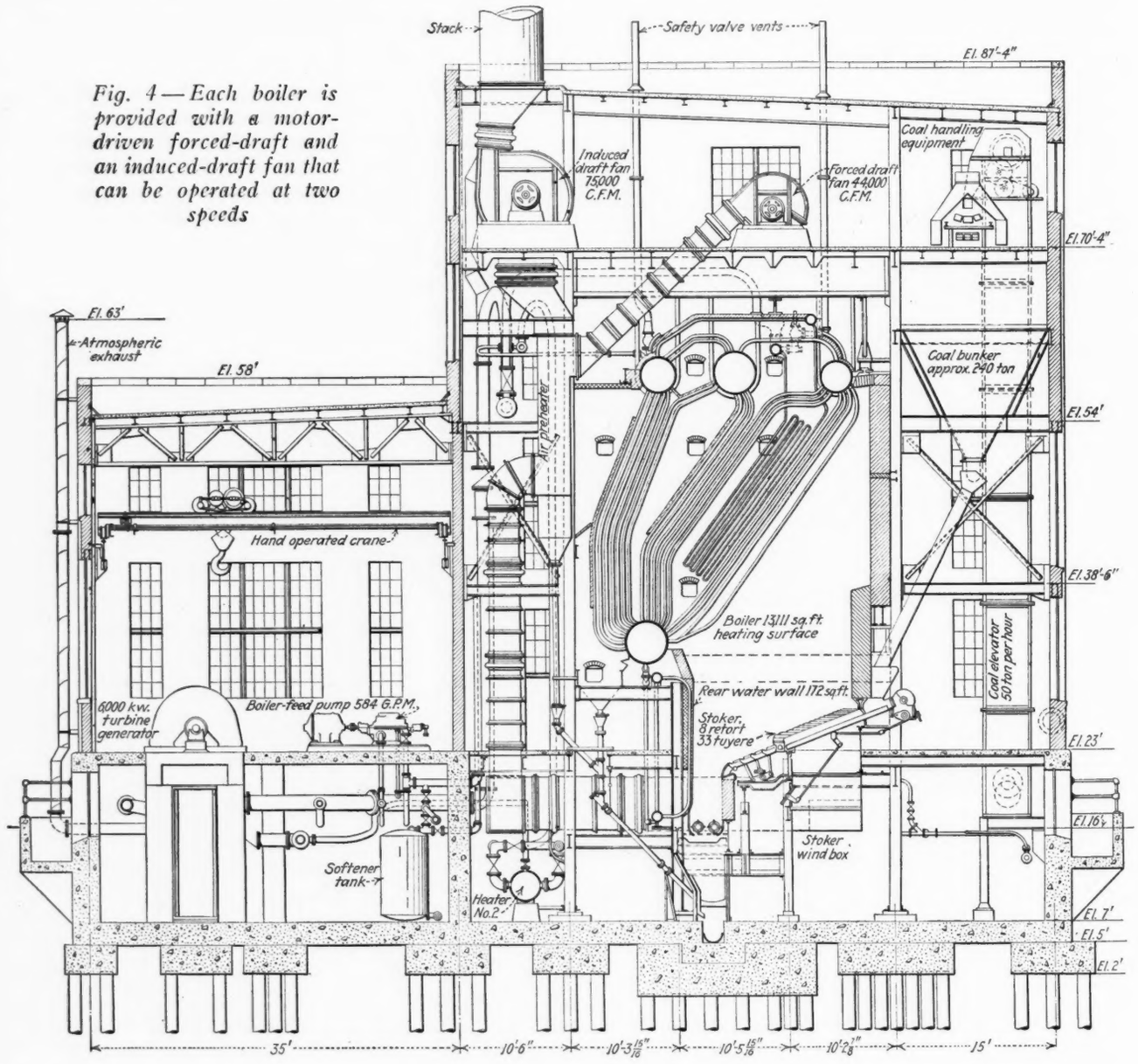


Fig. 4 — Each boiler is provided with a motor-driven forced-draft and an induced-draft fan that can be operated at two speeds

Cooling Refractories in BOILER FURNACES

Part Two—THE PRACTICE

By Ralph A. Sherman

Fuel Engineer, U. S. Bureau of Mines Experiment Station, Pittsburgh, Pa.

In Part One *Mr. Sherman gave a comprehensive picture of the theory of heat transfer in its relation to the cooling of furnace refractories. In this article he presents the results of several experiments in this field, shows the relation of practical to theoretical results, and gives a valuable summary of the effect of these conclusions on the actual construction of furnace walls.*

THE published progress reports of the field investigation of refractories service conditions in boiler furnaces, which was conducted jointly by the United States Bureau of Mines and the Special Research Committee on Boiler Furnace Refractories of the American Society of Mechanical Engineers, include a large number of measurements of temperatures in refractory walls by which the correctness of the theoretical discussion, which was published in the Oct. 29 number of *Power,* and the order of accuracy of the calculated values, may be checked.

Fig. 1 shows a typical time-temperature curve[4] which was taken in the 9-in. air-cooled wall in the zone of flame impingement in a furnace burning powdered Illinois coal. The temperature at ½ in. from the hot face rose quickly, but equilibrium was not attained, as shown by the continued rise in temperature at 6 in. from the hot face, until about 30 hours after firing, and equilibrium was not attained in each 16-hour period of operation following the banking periods.

Fig. 2 shows the temperature gradients through the brick of Fig. 1, which was at position 2, and through three other bricks in the same furnace 30 hours after lighting the burners.[4] The position of the bricks relative to the burners and the construction of the wall are shown in the figure. The temperatures at the hot face of brick No. 1, which was in the lower solid portion of the wall, and of brick No. 3, which was air cooled, were approximately the same, but the temperature gradient through the solid wall was about one-half as great as through the air-cooled wall, so that the temperature at 6 in. from the face of brick No. 1 was about 600 deg. F. higher than in brick No. 3.

The temperature of the gases at the face of brick No. 2, as measured by an exposed thermocouple, was about 2,800 deg. F.; this was also the temperature of the hot face of the brick as determined by extrapolation of the gradient curve. The temperature of the cool face, also by extrapolation, was 460 deg. F.; this is the same as that calculated for the 9-in. firebrick wall in a furnace at a temperature of 2,800 deg. F. and with air moving at a velocity of 1,200 ft. per minute, shown in Table II in the preceding article. The calculated temperature of the hot surface of the wall was 2,788 deg. F.,

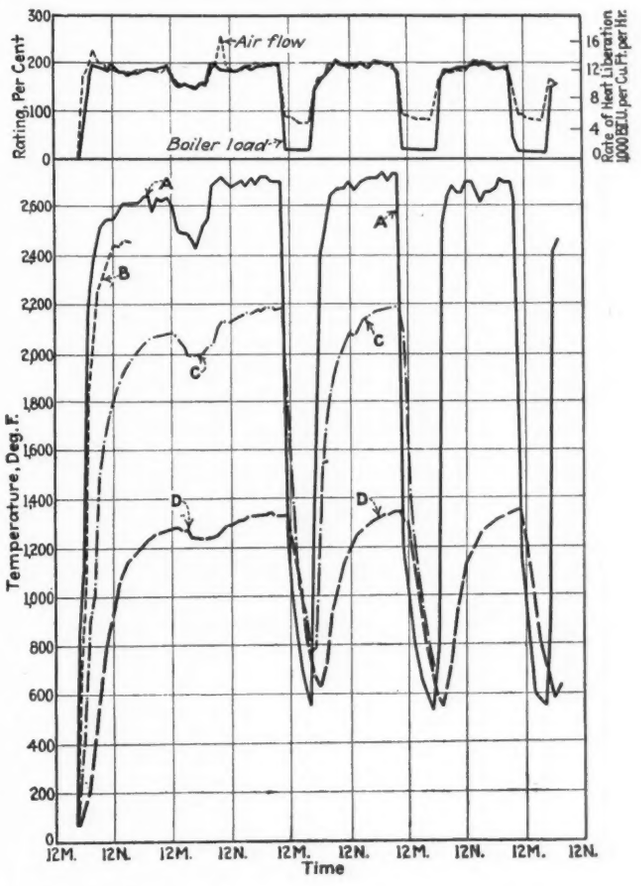


Fig. 1—Time-temperature curve in brick in zone of flame impingement on sidewall of furnace burning powdered Illinois coal

Couple *A*, ½ in. from hot face; couple *B*, 1 in. from hot face; couple *C*, 3 in. from hot face; couple *D*, 6 in. from hot face.

[4]Sherman, R. A., and Taylor, E., Refractories Service Conditions in Furnaces Burning Powdered Illinois Coal with Long-Flame Burners. Trans. A.S.M.E. Fuels and Steam Power Section, vol. 50, 1928, pp. 125-140.

a difference from the determined value well within experimental error. This example of agreement of the calculated and experimental values shows that although the actual conditions may not be the same as those assumed for the calculations, the over-all coefficients and results of Table II are representative.

Fig. 3 shows temperature gradients through a brick in the lining of a well-type burner box at the Sherman Creek station[5] of the United Electric Light and Power Company, New York City. The bricks were laid flat on the $4\frac{1}{2}$ x 9-in. face, with a bond of fireclay mortar between the bricks and the metal. The temperature at the hot face of the bricks when thermal equilibrium was established was about 2,425 deg. F., while the temperature of the gas within the box varied from 2,500 deg. to 2,600 deg. F. The temperature gradient through the brick was about 730 deg. F. per inch. This is lower than would be calculated from the difference in temperature of the hot surface and the gas; the discrepancy may have resulted from an insulating layer of slag on the surface or from a lower emissivity coefficient than has been assumed.

The discussion of the theory of the transfer of heat and the calculations of surface temperatures was based on the assumption of a condition of thermal equilibrium in the walls. The data just presented and other data on wall temperatures show that this assumption is not correct, and during normal boiler operation of alternate steaming and banking periods the rate of heat transfer into the brick at the hot face is greater than that leaving it at the cool face. This results from the low diffusivity

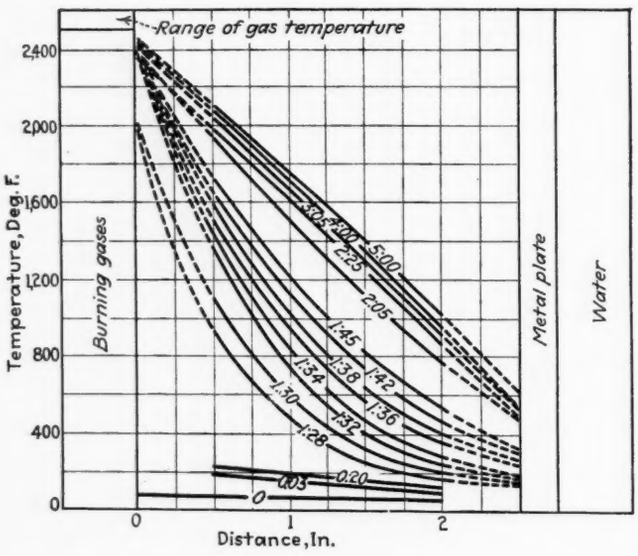


Fig. 3—Temperature gradient through brick in lining of a water-cooled burner box of a well-type furnace

—conductivity divided by the product of the density and the specific heat—of fireclay refractories.

The greater gradient at the hot face than assumed will result in lower temperatures at the face than calculated, but the difference will not be material. This is borne out in the data of Fig. 3, where the temperature of the hot face did not rise measurably, while that at 2 in. rose from about 200 deg. to 1,000 deg. F.

[5]Sherman, R. A., "Temperatures in Furnaces Having Extended Radiant Heating Surface," *Mechanical Engineer*, vol. 49, 1927, pp. 335-338.

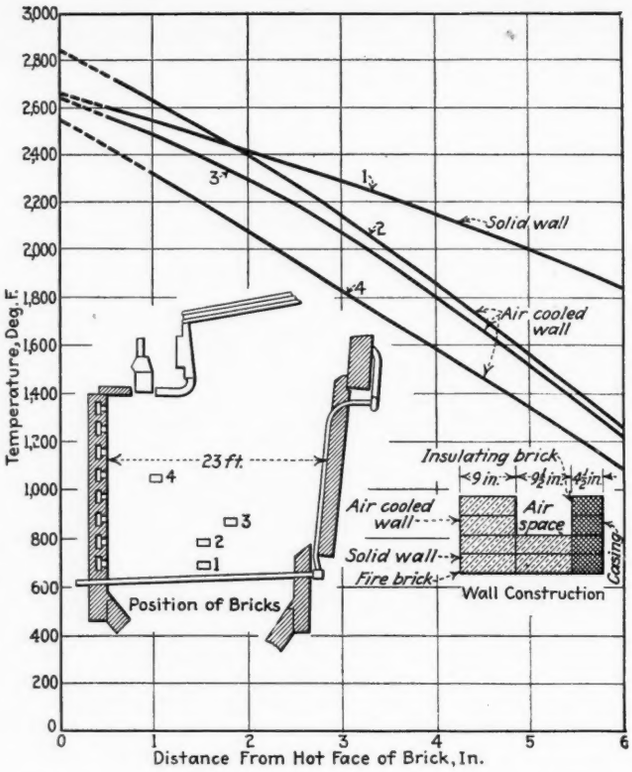


Fig. 2—Temperature gradient through bricks in walls of powdered-coal furnace 30 hours after lighting

Boiler load, 185 per cent of rating. Rate of heat liberation 11,600 B.t.u. per cubic foot per hour.

Fig. 4 gives data presented by Bailey[6] on temperature gradients through the elements of water-cooled refractory walls made by casting onto a thin refractory tile an iron block which is machined to fit the water tube and clamped tightly with a cement between the cast-iron block and the tube. Three types of blocks are shown through which rates of heat transfer of 18,000 to 50,000 B.t.u. per square foot per hour were obtained. The temperatures of the furnace were not given, but these have been calculated on the assumption of an emissivity of 0.9. It is improbable that the assumptions are correct enough to result in exact values, but they are close enough for purpose of comparison.

The type *CAF* block was stated to be of silicon carbide; the mean thermal conductivity through it was about 90 B.t.u. per square foot per hour per degree Fahrenheit per inch; the surface temperature was 1,550 deg. F., and the calculated furnace temperature was 2,180 deg. F. The material of the *BA* and *WAB* blocks was not specified, but, as their conductivities calculated were 30 and 26, respectively, it was probably alumina. The temperature of the hot face of the *BA* block was 2,000 deg., and the calculated furnace temperature was 2,300 deg. F.; the temperatures of the hot face and the furnace for the *WAB* block were, respectively, 2,300 deg. and 2,430 deg. F.

As these walls probably made up the greater part, or all, of the walls of the furnaces in which they were installed, the total rate of heat absorption by the walls, particularly for the rates of 33,000 and 50,000 B.t.u. per square foot per hour, must have been large relative to the rate of heat liberation in the furnace, and the

[6]Bailey, E. G., Some Factors in Furnace Design for High Capacity. Trans. A.S.M.E., Fuels and Steam Power Section, vol. 50, No. 33, 1928, pp. 226-267.

mean temperature of the flame, as well as that of the surface of the walls, was, therefore, lowered.

That fireclay refractories were not used for these blocks is worthy of note. If they had been used, the thickness for the same rate of heat transfer would have been one-ninth that of the *CAF* block and about one-third that of the *BA* and *WAB* blocks, which would be too thin to be made in this way.

The theoretical discussion and the experimental data which have been presented have shown that to obtain a measurable and effective reduction of the temperature of the hot face of a fireclay refractory it is necessary to reduce the thickness of the section of the wall as far as possible. With standard bricks the lower limit for walls which have the required strength is 9 in. The usual thickness of the refractory of walls of the sectionally supported type is not less than 9 in. At least one type of special block is on the market in which the section is only 3 in., probably the limit, as the leakage of air through thinner walls would be excessive.

The surface temperature of such walls cannot, therefore, be reduced enough to decrease greatly or to eliminate slag erosion under conditions of severe service, that is to say, high-furnace temperatures and easily fusible ash. The use of such walls is indicated, as generally recognized by designing and operating engineers, for moderately severe slagging conditions.

They present the advantages, previously discussed, of reduction of the possibility of deformation of walls under load, of increase in the efficiency of combustion by preheating the air, and of reduction in the radiation and convection loss from the furnace.

Another important advantage of the sectionally supported type over the solid or air-cooled wall of standard bricks is that the wall can be allowed to erode to a thinner section before it is necessary to rebuild it, and each small section may be replaced without disturbing other parts of the wall.

For severe service, water tubes may be used as a support for, and means of cooling, the required thin section of refractory. A facing of firebrick thin enough to obtain the high rates of heat transfer required would not be practicable. It is necessary, therefore, to use materials of high conductivity, such as alumina or silicon carbide, which are, incidentally, much more expensive.

The resistance to the transfer of heat from the cool face to the water must be made low; this requires careful design of the bond. As a rule, good thermal bond is obtained by special cements or gaskets and clamps to secure the block to the tubes.

Erosion cannot be entirely eliminated with this type of wall, however, as local high rates of heat liberation may result in such high rates of heat transfer that the temperature of the surface becomes high enough for rapid erosion, just as local hot spots may cause blistering of bare metal tubes.

The other advantages of water-cooled refractory walls have been previously enumerated, namely: Increase in steam-generating capacity, reduction in radiation and convection loss, and possible reduction of slagging of boiler tubes by lowering the furnace temperature.

Another type of cooling not previously discussed, but worthy of mention because of its wide and successful use, is that in which the water tubes are set on the hot face of the refractory wall. The effect of this type on the surface temperatures is not susceptible to as simple analysis as the direct-cooled wall, for the cooling is a combination of direct cooling by radiation from the

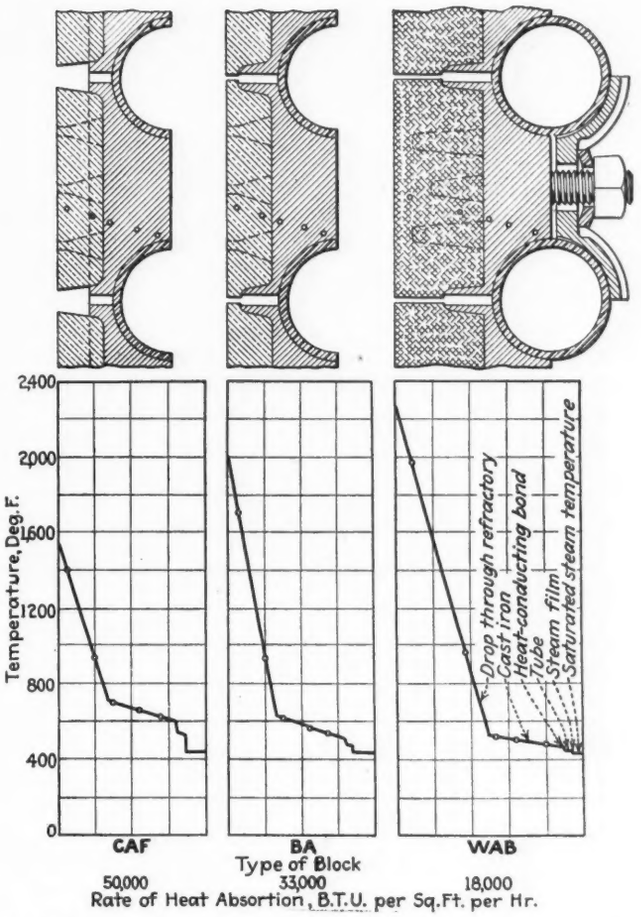


Fig. 4—Temperature gradients through refractory-faced blocks on water-tube side walls

refractory to the tubes and indirect cooling by reduction in the temperature of the flame and gases. The amount of cooling will depend on the spacing of the tubes and on the rate of total heat absorption relative to the rate of heat liberation. Slag frequently bridges across the tubes and effectively insulates the refractory. Local hot spots may occur, as with any method, with consequent rapid erosion.

The principles discussed and the supporting experimental data presented may be summarized as follows:

1. Because the greater part of the heat transfer to furnace walls is by radiation, high rates of heat transfer through the wall are necessary to reduce appreciably the temperature of the hot face.

2. To obtain high rates of heat transfer requires (*a*) the use of a thin section of refractory, (*b*) a refractory of high thermal conductivity, and (*c*) a high coefficient of transfer from the cool surface to the cooling medium.

3. The reduction in surface temperature by air-cooled walls is limited by the thickness necessary for strength and to prevent air leakage. Air-cooled walls are limited, therefore, to moderately severe slagging conditions, but they present important advantages.

4. Thin sections of refractory of high thermal conductivity can be used as a refractory facing for water-tube walls, and by proper design a high coefficient of transfer from the refractory to the water can be obtained. Such walls are indicated for severe slagging conditions and they, too, present other advantages.

Acknowledgment is made to P. Nicholls, supervising fuel engineer of the United States Bureau of Mines and a specialist in heat transfer, for helpful criticism of this article.

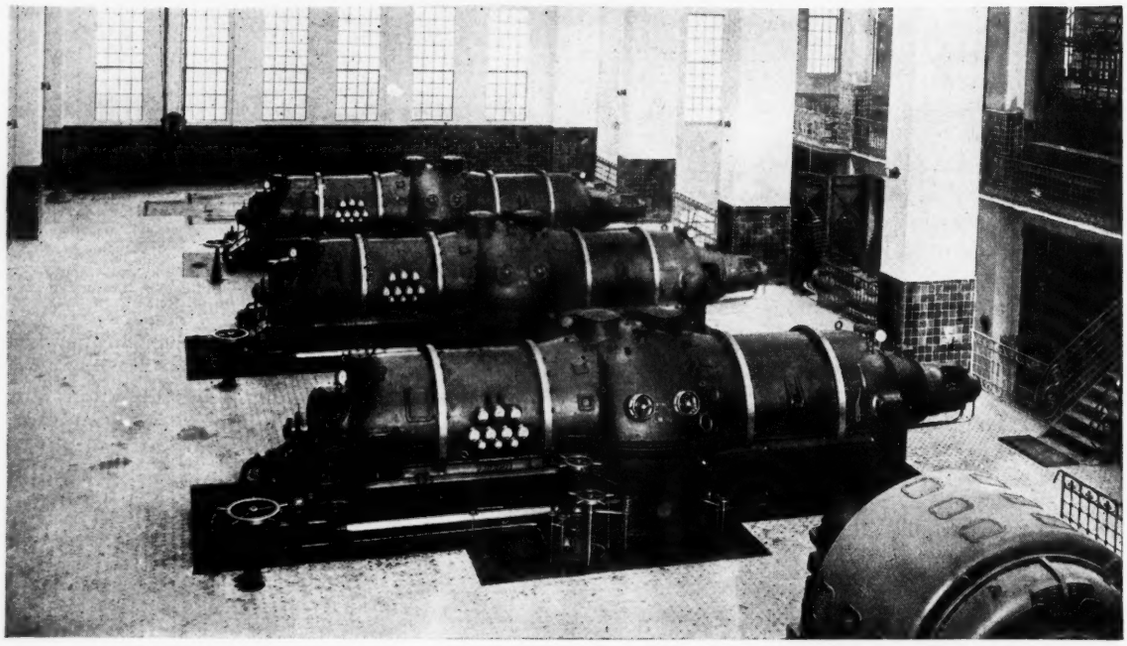


Fig. 1—Three 14,000-kw., radial-flow turbines installed at Livorno, Italy, using 700 deg. steam at 400 lb. pressure

Improvements in the DOUBLE-ROTATION TURBINE *Make Large Units Possible*

By O. A. Wiberg
Finspong, Sweden

IN MODERN steam turbine design there are two conflicting requirements, which have influenced, to a very marked extent, development during the last decade. One is the requirement of a high specific speed, leading to small physical dimensions and favorable conditions of temperature distention. The other is a large discharge area (annular area at right angles to the direction of steam flow in the last row of blading), leading to small discharge losses. This area varies, roughly, as the inverse square of the speed for constant mechanical properties of the blade material, so that a high specific speed and a large discharge area are difficult to combine.

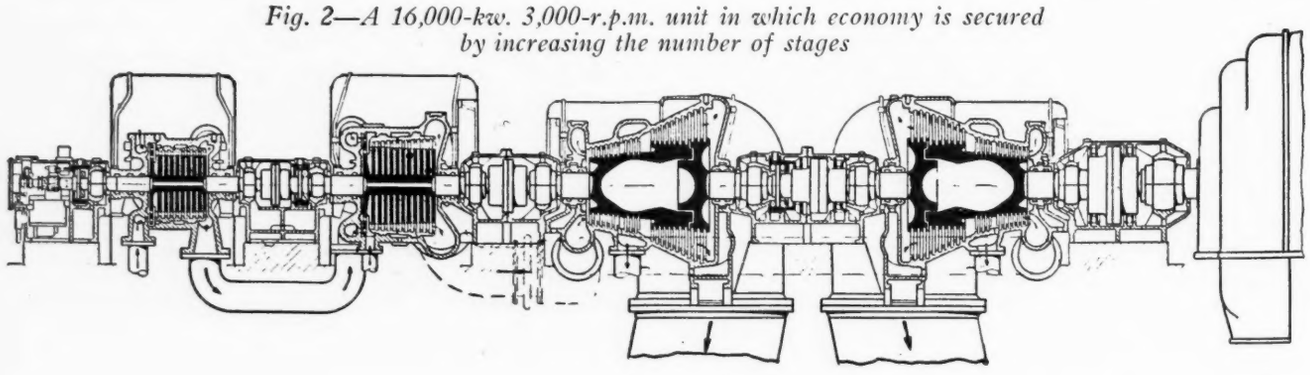
Both are essential to high steam economy, however; so that modern steam turbine designs represent compromises, justified to the extent that one or the other of the requirements with regard to steam economy or costs of construction is dominating. In general, it is a problem of increasing the discharge area to a maximum for each type of construction.

A variety of solutions has been employed for this purpose, of which the following might be mentioned:

1. Division of the unit into one high-pressure and two or several low-pressure units.
2. Division of the steam flow within the unit between two or several low-pressure wheels.
3. Bleeding of steam from certain stages in the low-pressure zones, thus reducing the discharge volume. The extracted steam is used for feed-water heating and, where possible, for other purposes.

Fig. 5 illustrates an example of the first method. Undoubtedly there is a decided improvement in the economy of each element, but the gain is offset, to some extent, by added convection, eddy, and friction losses, and a small amount due to the increased number of shaft

Fig. 2—A 16,000-kw. 3,000-r.p.m. unit in which economy is secured by increasing the number of stages



packings. While it is true that there are certain difficulties in the method of dividing the turbine into a high-pressure and a low-pressure unit, it is also true that the advantages are obtained without such excessive complications as have been used in more recent designs.

The second method, dividing the flow of steam within one cylinder, appears to be a more attractive solution. It can be stated, roughly, that the centrifugal stresses in the blading are directly proportional to the discharge area, for the same blade materials and the same speed, and almost independent of the ratio of blade length to mean diameter of the blading, within certain limits. The division of the low-pressure blading into two wheels would permit a doubling of the discharge area for the same limiting stress. The gain is obvious. The chief difficulty lies in accomplishing the division without undue complications and without introducing additional losses.

Fig. 4 shows an example where the steam is divided into two parts after passing the last stage in the high-pressure part. One-half of the steam continues directly through a stationary row to the last stage; the other half is carried through separate channels into a similar arrangement on the opposite side. This part of the steam has to reverse its direction of flow, involving appreciable losses.

Fig. 2 shows the complication to which turbine designers are willing to go in order to increase the number of stages and reduce discharge losses. This construction is of comparatively recent date and has 45 stages.

It is obvious from the above review of steam turbine development that most of the successful solutions of the turbine problem are characterized by a complicated external layout of the unit, resulting in high cost and large sensitivity to thermal distortions. In the Stal-turbine, in the form represented by the Ljungström-Wiberg radial-axial system, the desired results have not been obtained without complications in the design, but complications are confined to the rotating blade system, and the general layout is simple. The conditions of steam flow are satisfactory, and one of the outstanding characteristics is its insensitivity to thermal distortions.

The turbine is of the double-rotation type and consists, in its original form, of two intermeshed systems of blading, rotating in opposite directions; thus the ordinary systems of stationary blading are replaced by rotating systems, so that the relative speed is twice the speed of rotation of each end.

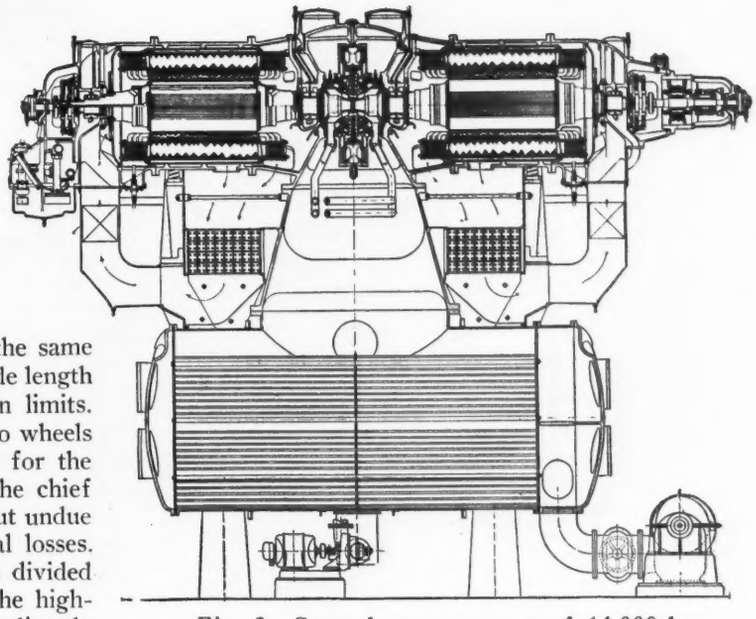


Fig. 3—Several arrangements of 14,000-kw. 3,000-r.p.m. radial flow turbine

In this form the requirement of a high specific speed was fulfilled, but it was not until the addition of axial low-pressure systems of ordinary blading that the requirement of a large discharge area was met. The steam, upon leaving the radial system of blading, is divided into two equal parts, and after expanding through the low-pressure stages it discharges directly to the condenser in a naturally wide passage without obstructions.

Fig. 11 shows a cross-section through the blading of a 14,000-kw. 3,000-r.p.m. turbine of this type in its original form. Fig. 12 shows a similar cross-section of a modern turbine of the same size. A comparison between these cross-sections shows the more important improvements made in the detail construction of blading. Fig. 3 shows the general layout of this unit.

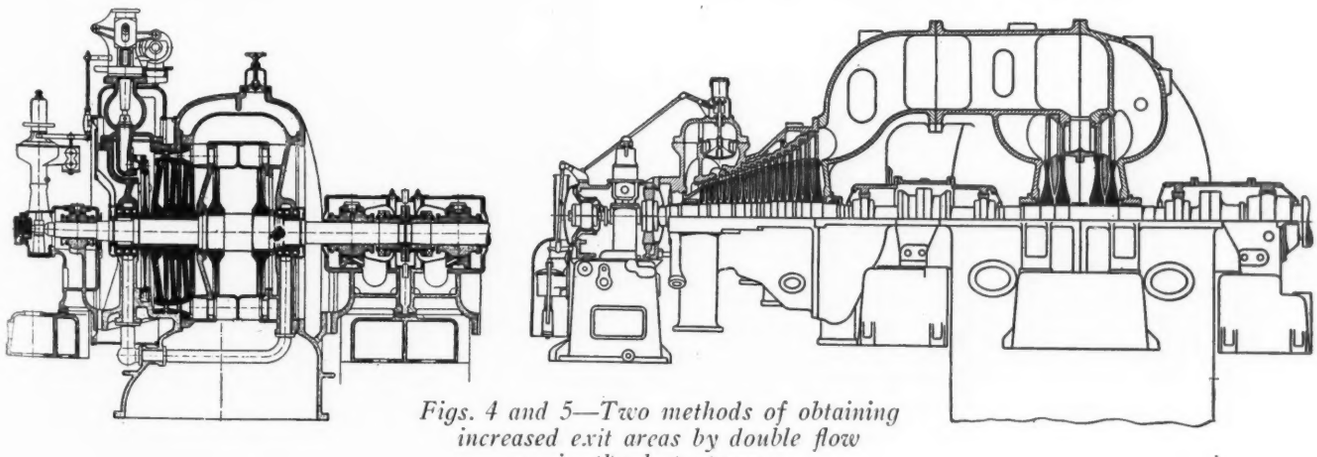
The possibilities of this turbine with regard to steam economy are best illustrated by the *quality factor*.

In England and in America the quality factor is usually expressed as

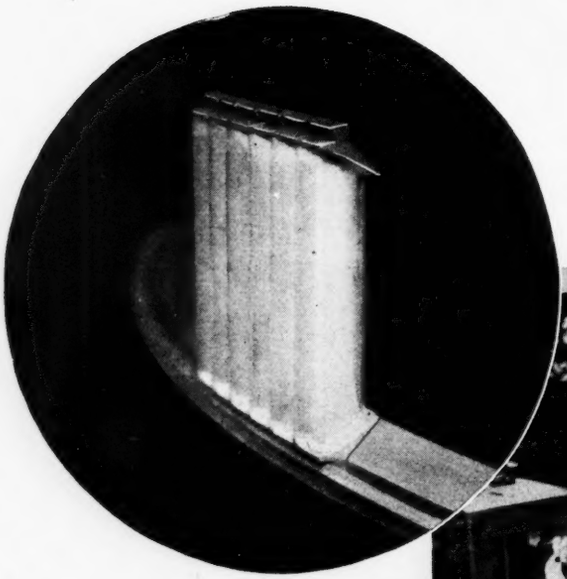
$$k = \Sigma \left(\frac{d}{10}\right)^2 \left(\frac{n}{100}\right)^2 = 10^{-6} \Sigma n^2 d^2,$$

where n is the r.p.m. and d the mean diameter in inches of each rotating blade ring.

In those turbines of ordinary type, where the attempts



Figs. 4 and 5—Two methods of obtaining increased exit areas by double flow in the last stages



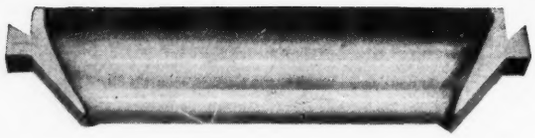


Fig. 8 (Above)—High pressure blading

Fig. 6 (Above)—Fastening of blades in ring

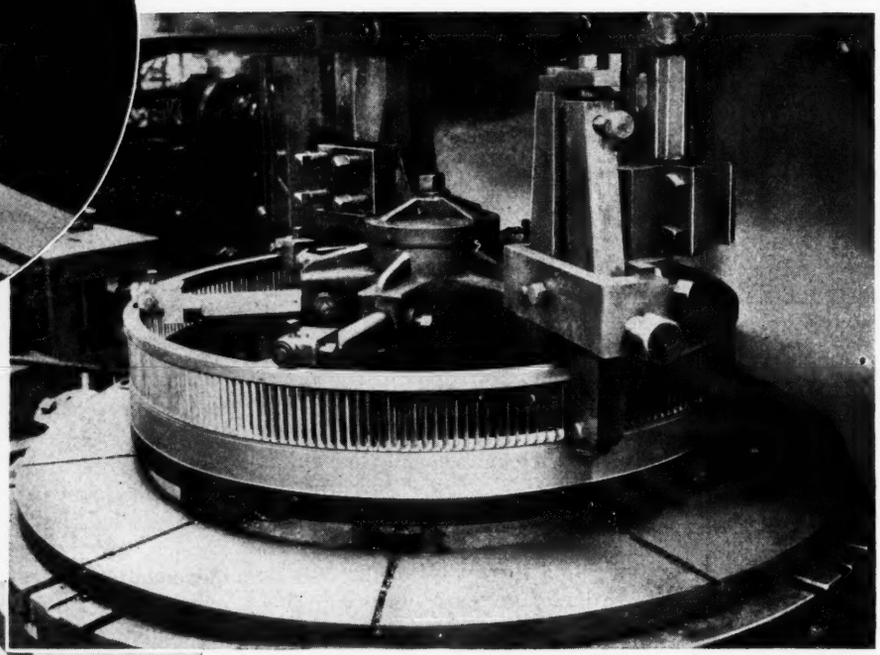
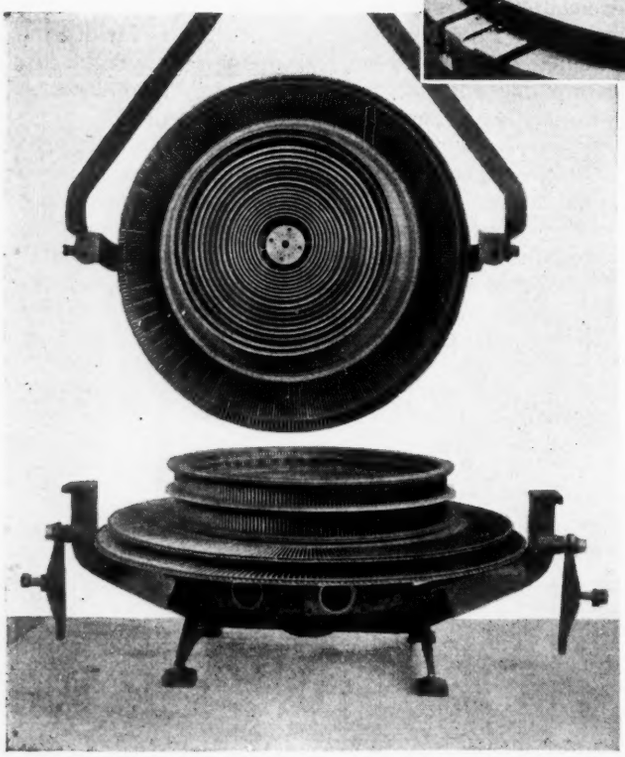
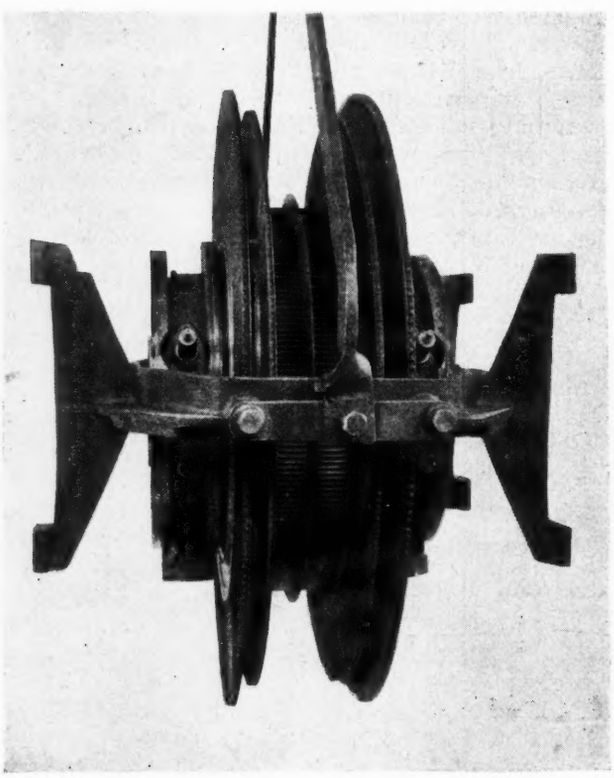


Fig. 9 (Above)—Rolling of dove tail in blade ring making possible the use of alloy-steel blading



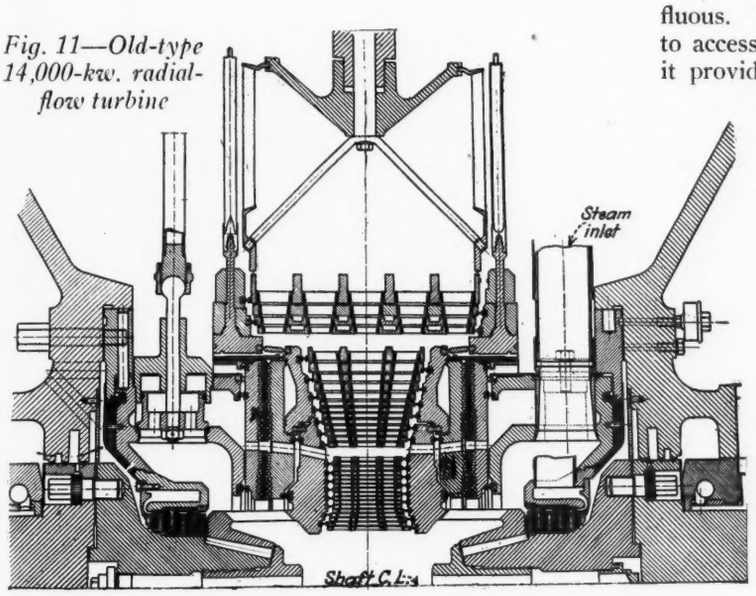


Figs. 7 (Above) 10 (Right)—Assembling rotating system. A centering pin is put through the hole in the center of the shaft, permitting the system to be assembled or taken apart without injury to the blading and gland rings

to improve the steam economy have been carried the farthest, it has been possible to attain values of the quality factor of $k = 483{,}000$. For example, the turbine shown in Fig. 2 has $k = 463{,}000$. Both of these turbines represent extreme designs requiring considerable complications in the general construction.

In the Stal-turbine a value of $k = 455{,}000$ is entirely normal for 3,000-r.p.m. machines; for 1,500 r.p.m. machines values of $k = 680{,}000$ are obtained with a normal construction.

Fig. 11—Old-type 14,000-kw. radial-flow turbine



TESTS ON A 12,000-KW. STAL-TURBINE DELIVERED TO THE KRAFTWERK HOMBURG, GERMANY

	Test Number			
	1	2	3	4
Duration of test, min	60	60	60	30
Abs. pressure before steam inlet valve, lb. per sq.in.	217	220	216	230
Abs. pressure after steam inlet valve, lb. per sq.in.	210	165	213	83
Abs. pressure in turbine exhaust, lb. per sq.in.	0.59	0.44	0.75	0.31
Steam temperature before steam inlet value, deg. F.	676	645	352	622
Steam temperature after steam inlet valve, deg. F.	691	634	341	605
Steam temperature in turbine exhaust, deg. F.	85	76	92.8	66
Generator output, kw.	11,931	8,450	14,436	4,358
Quantity of condensate, lb. per hour	114,300	84,300	145,600	46,650
Steam consumption of ejectors and shaft packings, lb. per hour	1,720	1,367	2,028	1,055
Steam consumption of the turbine, lb. per hour	112,580	82,933	143,572	45,592
Specific steam consumption, lb. per kw.-hr.	9.45	9.81	9.93	10.47

Until recently it has been the general opinion, that the radial-flow turbine is limited inherently to small capacities. This conception might have been correct for the turbine in its original form, but the modern Stal-turbine, where the radial turbine has been combined with an axial low-pressure turbine, is particularly suitable for construction of large units.

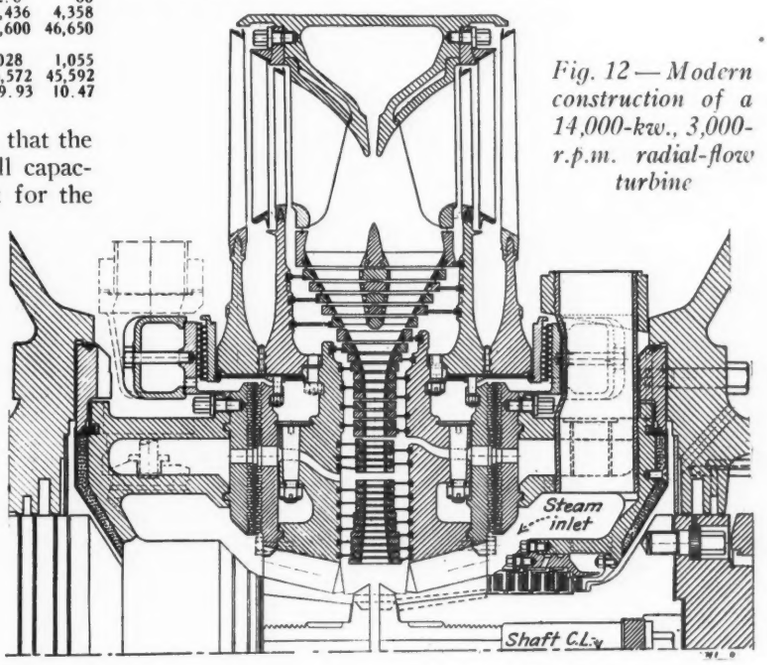
A feature that is closely associated with this question is the fact that the turbine is particularly free from thermal distortions. This is due to the small dimensions of the turbine, and to the favorable temperature distribution. The largest units that have been in operation for any considerable period of time—14,000-kw. at 3,000 r.p.m.—are started regularly by opening the throttle wide.

The small dimensions contribute to another important advantage, namely, low cost of the foundation structure. Fig. 3 shows a typical arrangement that can be maintained in its general form for all sizes. The turbine cylinder is built directly on the top of the condenser, and the two generators are overhanging, with flexible supports to carry their weight. Thus the stator material of the generators, the exhaust of the turbine, and the condenser are all taking part in the foundation function, so that additional material for this purpose is superfluous. This not only contributes to low cost, but also to accessibility to the auxiliary equipment. In addition it provides a dynamical machine system in which it is particularly easy to guard against vibration troubles, troubles due to thermal expansions and permanent changes in the supporting ground work.

Of the most important improvements in the detail construction in recent years might be mentioned the method of fastening the blading in the blade rings. Originally this was done by welding, a method which the operation of many units proved to be satisfactory from the point of view of strength and safety. It, however, excluded the use of alloy steels and non-corrosive materials in the blades. At the present time the blades are made of drop forgings and are fastened by dovetails to the blade rings, as shown in Figs. 6 and 8. The groove in the blade ring is machined open, and the ring material is rolled over, as shown in Fig. 9. As a result of this improvement it has been possible to use longer blades, particularly in the last rows, where as many as five sections were necessary with the old construction. In the present construction it is not necessary to use more than two sections.

There is now under construction a 50,000-kw., 1,500-r.p.m. unit for installation at Västeräs, Sweden. This is the largest unit actually under construction, although designs have been made for units of over twice this size. The span of the turbine room in this plant was selected originally for a 15,000-kw. unit as the maximum size. The new 50,000-kw. unit occupies an axial length equal to that of a comparatively recent 15,000-kw. 3,000-r.p.m. axial turbine of ordinary construction.

Fig. 12—Modern construction of a 14,000-kw., 3,000-r.p.m. radial-flow turbine



A.-C. *and* D.-C. MOTORS *Drive Power Plant Auxiliaries*

Forced-draft fan control

Direct-current motors are used on the essential auxiliaries and alternating-current on the non-essential in Delray No. 3. This combination provides a flexible and efficient means of obtaining adjustable speed where it is required and gives simplicity to the constant-speed drives. Manual control was chosen for all motors.

By H. E. LONGMIRE
General Electric Company
Detroit, Mich.

CONTROL for electrically driven steam power plant auxiliaries must meet different conditions than in the usual industrial applications. The control equipment required for the essential and non-essential auxiliaries will depend upon whether alternating- or direct-current motors, or both, are used. Each electric-drive application presents certain control requirements, depending upon the mechanical equipment used and the type of operation desired.

Direct-current motors are used for the essential auxiliaries at the new Delray power house No. 3 of the Detroit Edison Company, and alternating-current wound-rotor and squirrel-cage motors are used for the non-essential auxiliaries. Generally speaking, all motors in the turbine, condenser, and boiler rooms are direct-current driven, and all motors for the screen house, rotary car dumper, coal-breaker house, and coal conveyors are alternating-current driven. All alternating-current motors, with the exception of the squirrel-cage motors in the screen house, are of the totally inclosed fan-cooled wound-rotor type. Manually operated control equipment was chosen for all the auxiliary motors for simplicity and duplication of similar equipment in other power stations of the Detroit Edison system.

The controls selected for the direct-current motors are of the unit-type, as shown in the figures. The air circuit breakers, magnetic locks, ammeter, relays, and drum switches, with necessary panel wiring, are mounted on ebony asbestos bases supported by angle-iron framework suitable for floor mounting. The armature and field resistors are mounted at the back of the panel within a suitable sheet metal inclosure, with necessary ventilating sections at the top and bottom of each side.

The various direct-current control equipments differ somewhat, depending upon whether they are used on adjustable- or constant-speed motors. Practically all the essential auxiliary motors are of the shunt-wound, adjustable-speed type, the field resistor being designed to give a straight-line characteristic between the motor speed and resistor points. All controls for constant-speed motors are provided with manually operated starting-drum switches mounted on the control panels. The controls for the adjustable-speed motors differ, depending upon the application. Some of the controls are provided with combined starting and regulating drum switches, some have separate starting and regulating drum switches, while others have starting drum switches and motor-operated field rheostats. In each case interlocking is provided between the starting and speed-regulating devices and the hand-operated air circuit breakers. This prevents the operators from starting the motors unless the starting and speed-regulating devices are in the "off" position.

The speed of the clinker grinder, stoker, induced- and forced-draft fan motors is controlled from a boiler-gage board installed for each boiler. Regulating-drum switches for the clinker grinders and stoker motors are at the rear of the boiler-gage boards and are operated from the front by hand wheels. The induced- and the forced-draft fan motor controls are equipped with motor-operated field rheostats. Speed adjustment on these motors is made from control switches mounted on the boiler-gage boards.

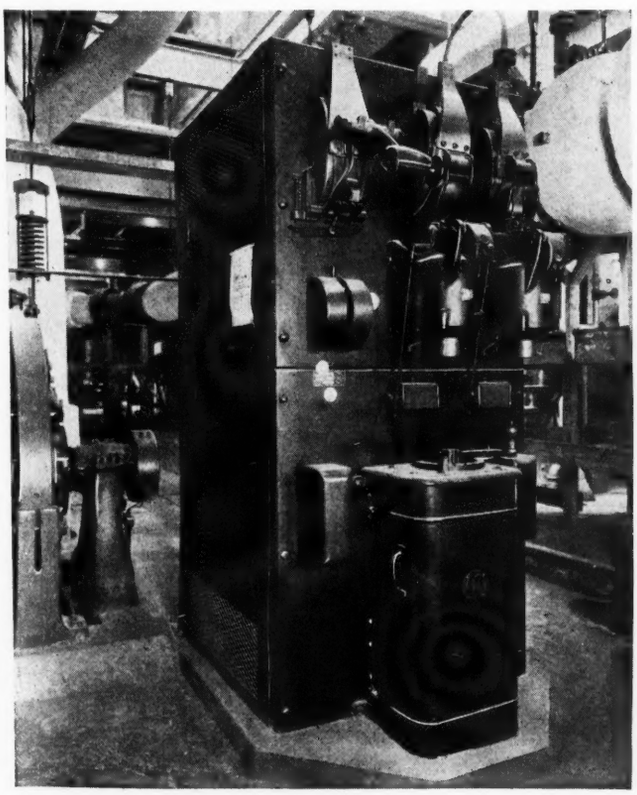
On the smaller control equipments, hand-operated,

double-pole, air circuit breakers are used. One hand-operated air circuit breaker and one or more solenoid-operated air circuit breakers are employed on the larger equipment. When more than one solenoid-operated breaker is used, the second circuit breaker will act as a short-circuiting switch for the starting-drum controller.

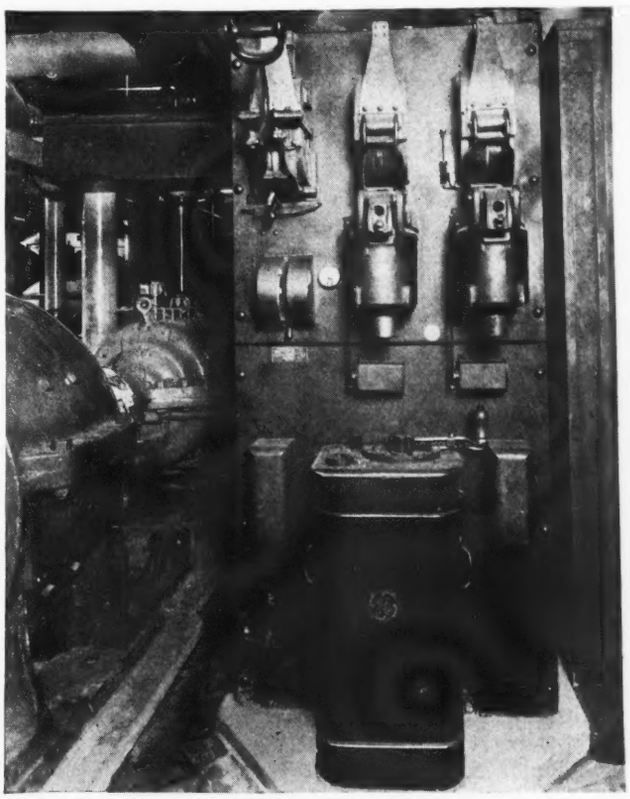
The air circuit breakers on the direct-current motor controls are rated 200 per cent full-load current of their motors and have a calibration up to 300 per cent full-load current. The overload trip coils are set to trip on excessive overloads or short circuits only. These controls do not provide for tripping on loss of voltage.

Control equipment for the wound-rotor motors, with the exception of the control for the rotary car-dumper motor, includes unit-type control panels, consisting of 600-volt, hand-operated oil circuit breakers with magnetic interlocks, trip coils, current transformers, time relays, overload relays, ammeter, drum switch and regulating-duty resistor. All of this equipment is assembled in a framework structure, with the resistor units mounted at the back, and within a sheet metal inclosure having ventilating sections of expanded metal at the top and bottom of each side. All live parts on the front of the panel are inclosed. The drum switches on the alternating-current equipment have off-position segments to prevent the oil circuit breakers being closed unless the drum switch is in the off position, thus providing full starting resistance in the motor secondary circuit. The secondary resistors are designed for continuous service at approximately 50 per cent speed reduction.

Protection is provided by thermal overload relays. The primary oil circuit breakers are not equipped with undervoltage devices. Should the voltage drop, however, triple-pole contactors will open, inserting approximately 20 per cent resistance in the secondary circuit of the motor. On resumption of voltage the motor will be started and the contactor, governed by a time-delay relay, will close after a definite time interval. Starting under these conditions is rather severe; but this will occur only in case of emergency.



Boiler-feed pump motor control



Induced-draft fan control

The induced- and the forced-draft fan motor controls are equipped with motor-operated field rheostats, and speed adjustment on these motors is made from control switches mounted on the boiler-gage boards.

The small squirrel-cage motors included with the non-essential auxiliary motors have across-the-line magnetic starting switches, and the larger motors have oil circuit breaker control panels.

The control panel for the rotary car-dumper motor includes the necessary reversing contactors, accelerating contactors, geared time interlocks, overload relays, control switch and resistor. An emergency switch and suitable master control switch are mounted remote from the control panel. The master switch provides three points forward and three points reverse, in addition, having an off-position segment for operation of the undervoltage contactor. There is a limit switch for slow-down and limit points.

Approximately half of the motors for the coal-handling conveyors are provided with shunt-wound, floor-mounted solenoid brakes. As the conveyors will be driven by the motors through reduction gears, with a consequent braking effect on reversal of rotation, relatively small brakes are required.

Each of the coal-handling conveyors is 455 ft. long. Each conveyor is driven by a 150-hp. motor equipped with a shunt-wound brake. In case of mechanical trouble, such as a broken motor coupling or conveyor belt, a centrifugal switch on one of the conveyor pulleys will operate on reversal of rotation and apply the brake on the pinion gear shaft, on the side opposite to the motor. This will prevent any serious piling up of the coal at one end of the conveyor.

Conversion of Sodium Carbonate *to* Caustic Soda *Within* Steam Boilers

An investigation by the author indicates that much of the sodium carbonate in boiler water is quickly changed to caustic soda. In certain cases the presence of sugar or other organic compounds may make ordinary indicators unreliable.

By C. E. Joos
Engineer, Cochrane Corporation

HIGH temperatures and pressures influence chemical reactions strongly. Sodium carbonate, or soda ash, present in boiler water (either naturally or as the result of chemical treatment by soda ash, boiler compound, a lime-soda softener or a zeolite softener) undergoes a transformation under steam conditions. Because of the temperature and pressure, it loses its content of carbon dioxide and is converted to caustic soda, as indicated by this formula:

$$Na_2CO_3 + H_2O = 2NaOH + CO_2$$

The carbon dioxide escapes with the steam, while the caustic soda gradually concentrates, together with the other solids, in proportion to the rating, modified by blowdown and steam quality. Generally speaking, the conversion of carbonate to caustic varies as the pressure and the rating. Practical observations indicate that pressure is the more important factor.

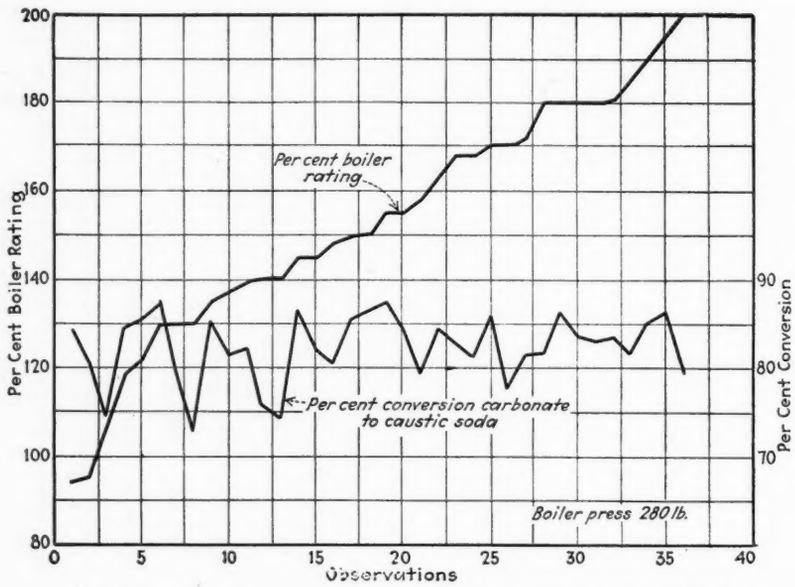


Fig. 2—Test showing that maximum conversion is affected only slightly by boiler rating

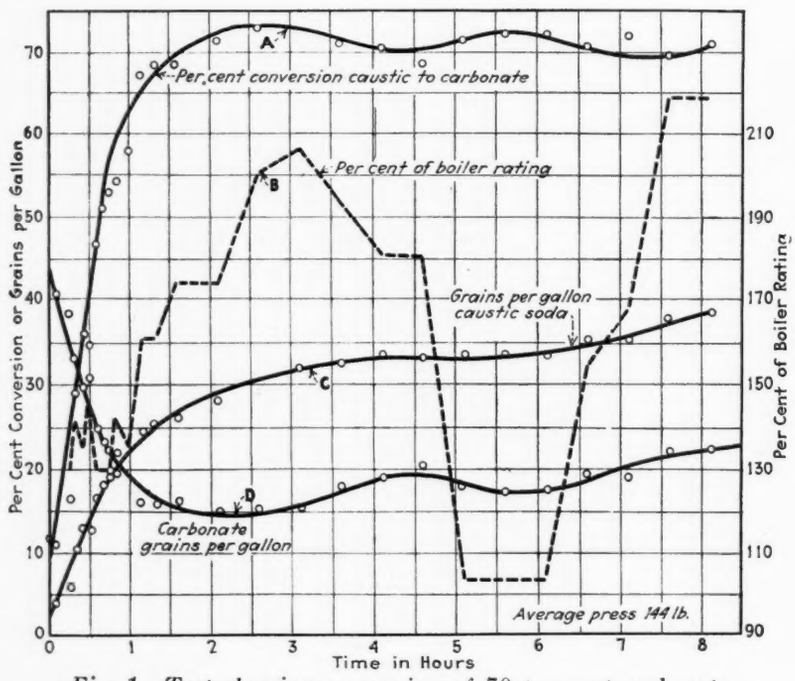


Fig. 1—Test showing conversion of 70 per cent carbonate in two hours of operation

In order to observe the progress of this conversion of sodium carbonate to caustic soda, a 5,000-sq.ft. boiler, generating steam at 145 lb. per square inch, was used for experimentation. Fifty pounds of soda ash was placed in the drum and the boiler was filled with freshly treated water from a hot-process lime-soda softener. The boiler was then fired gradually and observations were made at regular intervals of the conversion of carbonate to caustic. At the same time steam pressure and load were noted.

The results of this experiment, as set forth in Fig. 1, illustrate clearly the progressive conversion of carbonate to caustic. It will be noted that before any steam was delivered, a conversion of approximately 11 per cent took place. With generation of steam, as shown by the rating curve, the conversion of carbonate to caustic gradually increased, until after two hours the maximum degree of conversion was reached and then remained practically constant.

Another test over a longer period, and

at a pressure of 280 lb., is shown in Fig. 2. This test covered about a month's time, the observations being daily readings. The chart indicates an average conversion of approximately 82 per cent. It is clear from the curve that rating bears little relation to the amount of conversion, although a slight increase in conversion at higher ratings is indicated. These two examples indicate a conversion of approximately 72 per cent at 145 lb. per square inch and 82 per cent at 280 lb.

In order to get a general idea of the conversion that might take place under various conditions, a survey was made of plants in different sections of the country, with boilers operated at different pressures and treating the feed-water supply by different methods. Table I is a summary of the results observed.

It has been observed that where the feed water is contaminated by organic matter, such as sugar, tannin, etc., the apparent conversion is reduced, so that in many cases there is apparently no conversion where as much as 70 to 80 per cent would otherwise be expected. The reason for this is that certain organic substances, such as sugar and tannin, form a salt of calcium having methyl orange alkalinity but lacking phenolphthalein alkalinity. In this case the caustic which is present is obscured by the ordinary indicators used for boiler water testing. The presence of these organic calcium salts is readily indicated by the addition of ammonium oxalate to a sample of filtered boiler concentrate, upon which a heavy precipitate of calcium oxalate is usually produced.

This condition was studied in detail at a plant using water treated in a hot-process lime-and-soda-ash softener and having approximately 75 per cent condensate returns, which at times carried cane sugar from processes. In this instance the sugar was apparently changed to an acid which partially neutralized the boiler alkalinity, at the same time forming an organic calcium salt, calcium saccharate, and obscuring the true amount of caustic soda present.

The data given in Table II illustrate the effect of this sugar contamination, not only in its neutralizing effect on the boiler alkalinity, but also its effect in obscuring the caustic soda when the ordinary indicators, phenolphthalein and methyl orange, were used. At one time the sugar contamination was so great that the boiler alkalinity was reduced to a point where a dense calcium sulphate scale formed, causing several tube failures and showing the acid nature of such contamination.

To make apparent the acid effect of the sugar contamination, the phenolphthalein alkalinity, which is a more positive indication of the soda concentration than is the methyl orange alkalinity, is divided by the sodium chloride or salt concentration. This appears in the seventh column of Table II. The results indicate clearly the effect of

TABLE II—BOILER WATER CONTAMINATED WITH SUGAR

Date	Boiler Water Alkalinity Phenolphthalein (Ph.)	Boiler Water Alkalinity Methyl Orange (M.O.)	Salt	Per Cent Apparent Conversion to Caustic	Sugar in Boiler Concentrate Gr. per Gal.	Ratio Ph: NaCl	Unit Soda Ash Treatment
3/7	46.3	56.5	17.1	63.9	None	2.71	5.5
3/8	48.5	59.2	21.0	63.9	None	2.31	5.0
3/11	29.5	44.4	16.7	66.5	None	1.77	5.0
3/12	36.6	48.1	18.1	52.2	None	2.02	5.0
3/13	No Samples Taken		....	....	...	....	5.0
3/14	21.4	37.1	18.5	15.5	4.6	1.15	5.0
3/15	16.2	35.2	21.8	0.0	4.9	0.74	5.0
3/16	9.2	32.4	18.9	0.0	4.8	0.48	5.0
3/17	4.2	31.0	18.9	0.0	7.9	0.22	5.0
3/18	22.5	39.7	15.2	13.5	4.6	1.48	5.0
3/19	32.4	52.7	19.2	23.0	None	1.69	5.5
3/21	39.6	49.3	11.5	60.7	None	3.44	5.5
3/23	44.2	58.8	16.6	50.4	None	2.66	5.5
3/24	34.7	48.2	15.1	44.0	None	2.29	5.0

TABLE I—SURVEY TO DETERMINE EFFECT OF CONDITIONS ON CONVERSION OF CARBONATE TO CAUSTIC

Plant Location	Water Analysis Na_2CO_3	NaOH	Na_2SO_4	NaCl	Total Solids	Per Cent Conversion	Steam Press	Per Cent Rating	Method of Treatment
New Haven, Conn....	7.9	5.2	17.5	8.4	45.0	46.6	112	...	I
Morgantown, W. Va.	6.9	5.6	241.7	12.8	274.4	51.8	115	50	L. S.
Baltimore, Md.....	3.9	3.5	10.2	15.6	38.5	54.3	120	120	I
Paterson, N. J.....	15.8	16.4	61.6	19.2	138.0	57.8	120	80	I
Pittsburgh, Pa.....	10.9	1.9	140.8	12.4	167.2	18.0	120	90	I
Beaver Falls, Pa.....	7.9	6.3	165.8	74.0	255.9	51.2	120	125	I
Chelsea, Mass.....	18.7	29.4	22.6	11.2	.....	68.6	120	135	I
Cleveland, Ohio.....	17.8	12.7	18.6	48.4	162.0	48.3	120	140	I
Newark, N. J.....	10.9	13.8	28.5	9.2	76.8	62.4	120	165	I
Pittsburgh, Pa.....	6.4	11.9	64.6	19.0	108.5	71.0	125	...	I
Trafford, Pa.....	9.4	26.1	140.0	29.8	211.8	78.6	125	...	I
Trenton, N. J.....	14.5	15.3	105.0	44.6	209.9	58.5	125	...	I
Jersey City, N. J.....	13.8	5.0	80.0	23.8	143.0	32.5	125	...	I
Pittsburgh, Pa.....	10.9	7.4	258.8	16.0	295.5	47.2	125	...	L.S.
Philadelphia, Pa.....	11.6	14.3	56.2	14.2	107.5	61.9	125	90%	I
Binghamton, N. Y....	10.8	14.1	64.7	23.2	139.0	63.6	125	150%	I
McKeesport, Pa.....	9.4	3.0	171.0	24.8	208.0	29.3	130	140	I
Port Arthur, Texas...	22.2	24.2	122.8	485.0	663.7	59.0	130	225	L.S.
Harrisburg, Pa.....	16.8	65.4	150.0	11.4	204.8	63.7	140	...	I
Mishawaka, Ind.....	15.7	46.5	52.7	8.4	153.5	79.7	140	125	L.S.
Wilmerding, Pa.....	4.9	5.6	118.8	32.4	163.1	60.2	140	100	I
Naugatuck, Conn....	25.6	9.3	36.3	14.4	87.2	32.5	145	150	L.S.
Trenton, N. J.....	5.9	27.6	42.1	32.0	86.9	86.0	145	Banked	I
Brackenridge, Pa.....	10.4	24.8	50.9	23.0	102.5	75.8	146	216	L.S.
Pittsburgh, Pa.....	5.9	1.5	44.2	31.2	.....	25.2	150	...	I
St. Joseph, Mo.....	25.6	25.3	211.6	23.2	293.2	56.7	150	100	I
San Antonio, Texas...	3.9	15.8	....	43.6	.....	80.0	150	130	I
E. Pittsburgh, Pa....	18.7	35.8	281.7	52.4	432.5	71.6	150	150	L.S.
Parlin, N. J.....	6.9	15.2	22.4	8.4	53.3	74.6	150	167	I
Louisville, Ky.....	6.9	11.2	84.3	31.6	141.6	88.0	155	200–225	L.S.
Summit, N. J.....	22.6	40.6	31.8	14.8	128.3	70.3	160	...	I
Lincoln, Neb.....	2.95	8.6	43.2	11.2	105.6	79.3	160	...	I
Pittsburgh, Pa.....	6.9	5.2	123.8	36.0	.....	50.0	160	...	I
Pensacola, Fla.....	3.0	4.5	2.5	22.8	.....	52.8	160	110	I
New Ulm, Minn.....	49.2	45.5	271.5	82.0	448.2	55.1	160	150	Z
New Ulm, Minn.....	36.4	37.6	211.0	61.2	371.0	57.7	160	150	Z
Long Branch, N. J...	6.9	3.0	67.0	8.0	104.0	36.2	160	200	I
Pittsburgh, Pa.....	3.0	3.4	48.4	22.0	78.6	59.3	160	...	I
Pittsburgh, Pa.....	5.9	1.9	45.1	12.8	66.0	29.3	160	...	I
Toledo, Ohio.....	10.9	1.9	50.8	16.0	289.2	18.0	165	100	I
Flint, Mich.....	8.9	4.8	70.4	16.0	104.4	41.8	165	140	L.S.
Philadelphia, Pa.....	37.5	9.7	99.5	19.6	171.0	25.3	175	100	I
Laurel, Del.....	11.8	10.8	6.6	16.0	59.9	54.8	175	150	I
Pennsgrove, N. J.....	6.9	6.7	6.3	14.8	53.8	56.2	175	172	I
Pittsburgh, Pa.....	7.9	6.2	79.4	28.0	120.5	40.7	180	...	I
Pittsburgh, Pa.....	7.9	5.2	102.0	29.6	152.0	46.5	185	...	I
Charleston, W. Va....	8.9	3..5	15.9	6.0	44.8	34.0	190	...	I
Pittsburgh, Pa.....	1.2	1.0	12.1	13.0	31.6	51.3	180	...	I
Sandusky, Ohio.....	11.8	4.1	140.8	32.0	200.4	31.5	180	75	L.S.
Pittsburgh, Pa.....	6.9	3.0	48.1	24.4	.....	36.0	180	...	I
Pittsburgh, Pa.....	4.9	2.6	35.8	18.8	.....	41.3	180	...	I
Pittsburgh, Pa.....	4.9	4.8	78.2	26.8	.....	56.7	185	...	I
Hopkinsville, Ky.....	19.7	59.5	60.5	8.0	185.5	80.0	180	150	I
Harrisburgh, Pa.....	4.9	23.8	168.0	11.8	218.0	86.3	210	...	L.S.C.
Pittsburgh, Pa.....	9.0	5.2	144.5	42.8	206.0	46.2	200	...	I
San Antonio, Texas...	4.9	8.9	48.6	38.8	113.5	70.8	200	...	I
Philadelphia, Pa.....	9.8	24.2	82.4	12.0	152.0	76.8	200	170	I
Muskogee, Okla.....	9.8	9.3	30.9	68.8	103.9	55.7	225	...	Z
Muskogee, Okla.....	9.8	20.5	17.5	32.0	84.5	73.4	225	...	Z
Muskogee, Okla.....	22.7	53.6	47.0	48.0	215.0	75.8	225	...	Z
Muskogee, Okla.....	13.8	23.6	58.4	55.2	167.4	70.1	225	...	Z
Muskogee, Okla.....	10.8	22.0	29.9	59.9	131.1	72.9	225	...	Z
St. Augustine, Fla....	8.9	23.1	487.3	578.0	1,203.7	77.4	245	...	L.S.
Grand Rapids, Mich..	23.2	43.3	420.0	58.2	642.0	71.2	275	160	L.S.
Seward, Pa.....	5.9	20.8	9.3	6.4	46.7	82.3	280	...	L.S.
Seward, Pa.....	3.9	23.4	19.9	7.2	63.4	88.9	280	...	L.S.
Seward, Pa.....	6.9	19.4	18.5	8.0	65.5	78.7	280	...	L.S.
Seward, Pa.....	3.9	23.4	19.9	7.2	63.4	88.9	280	...	L.S.
Seward, Pa.....	5.9	26.4	16.5	12.8	74.8	85.5	280	...	L.S.
Seward, Pa.....	5.9	14.5	11.9	4.4	41.9	76.5	280	...	L.S.
Seward, Pa.....	7.9	31.6	16.9	8.0	80.5	84.1	280	...	L.S.
Harrah, Okla.....	7.9	20.5	35.4	82.0	147.2	77.4	300	...	Z
Harrah, Okla.....	9.8	22.5	37.3	92.0	172.0	76.6	300	...	Z
Denver, Colo.....	6.9	12.3	11.6	5.2	42.5	70.2	375	...	N.S.

I—Internal. L.S.—Lime soda or hot process. Z—Zeolite. N.S.—Natural soda. L.S.C.—Lime soda cold process.

sugar contamination in neutralizing the soda alkalinity.

Ordinarily, cane sugar will not affect the standard phenolphthalein and methyl orange readings, but within steam boilers the change occurring is important from the standpoint of boiler-water treatment. In the first place, the methyl orange alkalinity is made unreliable as a soda alkalinity indicator. Secondly, the actual presence of caustic soda is obscured, which may lead to wrong assumptions from the standpoint of caustic embrittlement control.

It is occasionally stated that some plants are immune to caustic embrittlement, even though the sulphates are low, because there is actually no caustic present. In all cases of this character, where a soda treatment is used it is found that the boiler concentrate contains organic matter which has the same effect as sugar in obscuring alkalinity. In such cases, where contamination is likely to exist, it is better to assume that the phenolphthalein alkalinity is the total soda alkalinity.

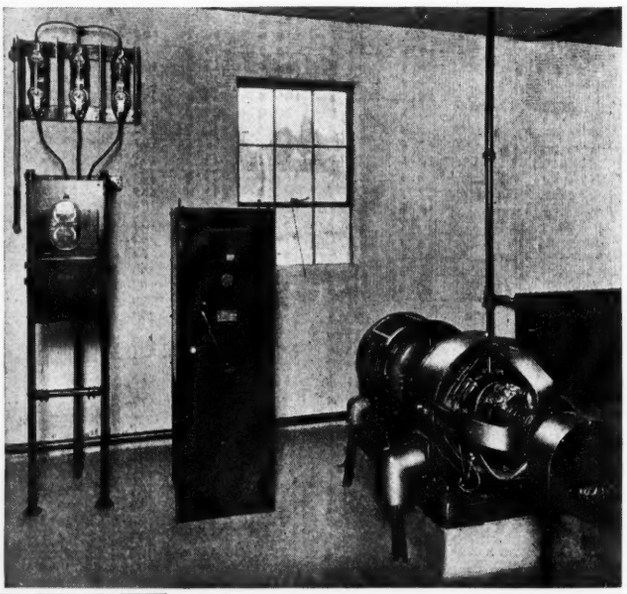
Two Power Sources Supply "Mount Vernon"

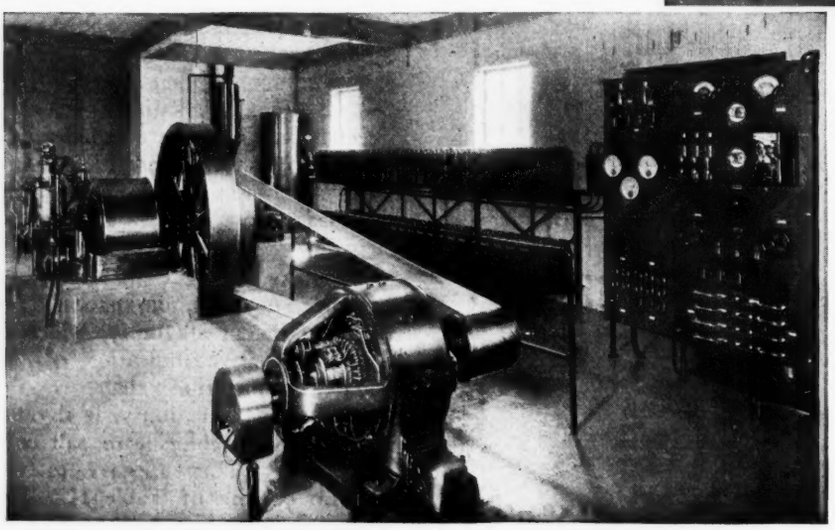
THE use of electricity at Mount Vernon, home of George Washington, was first considered in 1916. The owner of the estate, the Mount Vernon Ladies' Association, which is comprised of one member from practically every state in the Union, asked Thomas A. Edison to recommend a system that would be least likely to cause a fire. Mr. Edison recommended a low-voltage battery system. In 1917 a 32-volt battery and two 3¼-kw. oil engine generating sets were installed. This equipment was used for lighting the office and kitchen. The mansion proper has never been wired, as it is desired that it remain just as it was when Washington lived there.

By 1922 the load had outgrown the capacity of the 3¼-kw. generating sets. It was decided to build a larger power plant further from the mansion. This building was virtually a cave, sunk into the hillside between the front lawn and the river, with only one side exposed for an entrance. This made it invisible from the mansion and rendered the plant safe from lightning.

In this plant there were installed a 35-kw., 110- to 220-volt, 3-wire generator, a 50-hp. Diesel engine, and a battery consisting of 192 cells. This equipment furnished power for two electric ranges, for pumping water, for electric refrigeration, for ventilating buildings open to visitors, and for additional lighting. The operation was economical, the battery being charged for seven hours every other day. Crude oil shipped via the Potomac River and landed a few feet from the door of the plant was used as fuel for the engine. But later, to insure against a power failure, another source was sought.

In 1928 the Virginia Public Service Company extended a 2,300-volt line to the border of the estate, and a new fireproof power plant was built, well-concealed in a valley one-third of a mile to the rear of the mansion. The extension from the company's line to the plant is by underground cable. The new equipment for this plant consists of a 50-hp. induction motor direct-connected to a 35-kw., 125- to 250-volt, 3-wire generator. The oil engine, generator and battery from the 1922 plant will serve as auxiliary equipment in the new plant. The motor-generator set supplies the load in the daytime and charges the battery. The battery carries the load at night. The switching equipment is flexible: Either the motor-generator set or the engine set can be used for supplying the load direct or for charging the battery.





Above—Normally, power is supplied from a motor-generator set consisting of a 50-hp. induction motor direct-connected to a 35-kw., 125- to 250-volt, 3-wire direct-current generator

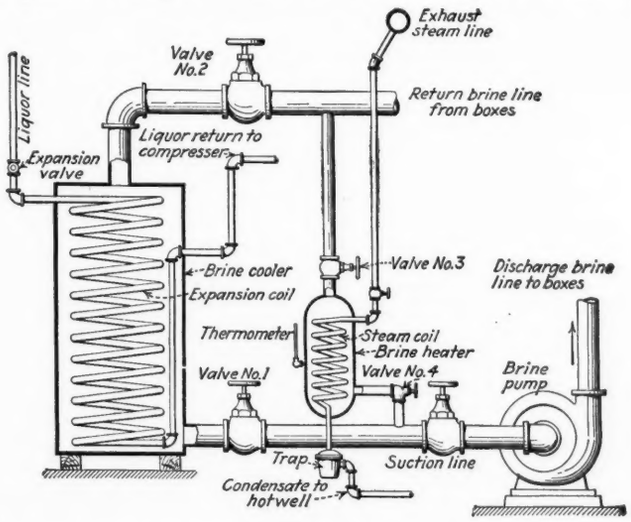
Left—For auxiliary service a 35-kw. Diesel engine driven, 3-wire, direct-current generator and a storage battery have been installed

Right Out of the Plant

How the Time Required to Defrost the Coils Was Reduced

THE illustration shows a little kink that we have been using for the last three years in defrosting the ice box coils in our plant.

The regular operation of the system calls for circulation through valve No. 1 to the brine pump, through all ice boxes and then through valve No. 2 to the brine cooler. During the defrosting operation the exhaust steam is cut into the brine heater until the thermometer registers 50 deg. F. Then valve Nos. 1 and 2 are closed



Brine is heated with exhaust steam for the defrosting operation

and valve Nos. 3 and 4 are opened, and the 50-deg. brine circulated through the system, the cold brine returning to the heater instead of to the cooler. The steam is left on the heater to maintain the 50-deg. temperature until defrosting is completed.

We defrost every two weeks in the summer and once a month during the winter. With this system it takes just an hour to defrost 22 boxes, whereas it used to take three to four hours with a hot-water hose and bars. Furthermore, with the present system nothing is disturbed in the boxes. Each box is equipped with a drain to care for the water resulting from the melting of the frost on the coils. LAWRENCE B. BROWN.

Los Angeles, Calif.

Why Flanged Pipe Joints Leak

IN A letter in the Oct. 22 number of *Power* entitled "Why Flanged Pipe Joints Leak," W. F. Schaphorst advocates the use of thick gaskets as a cure for leaky joints. He would have us believe that joints made with thick flexible metallic gaskets will remain tight under expansion and contraction stresses and that a thin gasket is more likely to leak. This, however, is not borne out in practice.

It has always been my opinion that provision for expansion other than that taken up at the flanged joints was necessary in a pipe line of any length. Thick flexible metallic gaskets will possibly take care of a very small amount of expansion, but it is just as important to make provision for the expansion when thick gaskets are used as it is with thin ones.

I have personal knowledge of a 6-in. flanged pipe line in which the flanged joints are made with pressed sheet asbestos $\frac{1}{16}$ in. thick. In this line provision is made for expansion and contraction, the steam is turned on and off the line several times an hour and the joints have remained steam tight for years.

The only advantage I can see to the use of a thick gasket is where the sections of the pipe may not line up just right, in which case the thick joints will take care of the slight out of alignment somewhat better than thin ones. J. E. NOBLE.

Toronto, Ont.

Smoke-Preventing Furnace Construction For Horizontal Return-Tubular Boilers

RUSSELL MELVILLE in the Oct. 1 number of *Power*, described very thoroughly what we term the "wing-wall" furnace, but as our experience has demonstrated the superiority of the "Plate 1" furnace as prescribed by the code of ordinances of the City of Cincinnati, it may not be amiss to describe its construction and action for the benefit of those municipalities that are struggling with the smoke problem.

The horizontal return-tubular type of boiler is generally used in small power plants, and installations of such boiler are greatly in the majority. Nearly all of the new installations of this type of boiler in Cincinnati are equipped with automatic underfeed stokers, but the majority of the old types are hand-fired, and in such the value of the "Plate 1" furnace for coal saving, as well as preventing smoke, is readily established.

Experience with the "wing-wall" furnace, as described in the article referred to, has shown the following weaknesses: First, the air ducts in the bridge wall become stopped up with ashes and dust and consequently become inoperative; second, there is insufficient interference with the travel of the gases to cause proper mixing of the air and gases; third, the air for the completion of the combustion is admitted at the rear of the fire instead of in front, where it is most needed, as obviously there is small chance of completing the mixture and obtaining perfect combustion after the gases enter the tubes.

There have been a number of trials of patented furnaces containing ducts built into the side walls and bridge wall and opening at the rear of the fire in Cincinnati, but none of them has been satisfactory, for the reason that the ducts become stopped up or require too much attention to be kept open. It is quite necessary that such construction be made as "foolproof" as possible.

The combustion of coal by destructive distillation is an interesting chemical experiment, but it is difficult to convince the man with the shovel that such is the case. The modern plant owner is beginning to realize the value

TABLE OF PRINCIPAL DIMENSIONS AND AREAS

(All dimensions in inches except B)

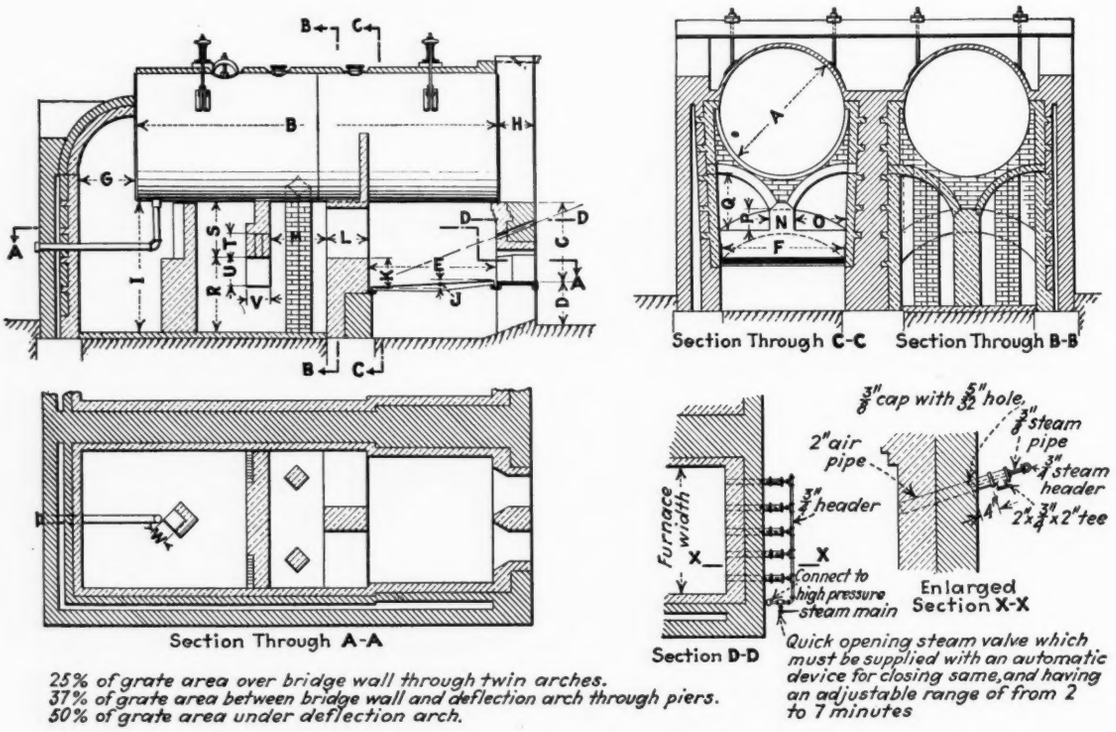
A	84	84	78	78	72	72	66	66	60	60	54	54
B	20	18	20	18	18	16	18	16	18	16	16	14
C					36	36	36	36	36	36	36	36
D					24	24	24	24	22	22	22	22
E					72	66	66	60	66	60	54	48
F					72	72	66	66	60	60	54	54
G					30	30	28	28	26	26	24	24
H					20	20	19	19	18	18	17	17
I					71½	66½	67	61½	69	64	59	56
J					6	5½	5½	5	5½	5	4½	4
K					18	19	19	20	17½	18½	19½	18
L		Mechanical stokers must be installed on these sizes			24	24	22½	22½	22½	22½	18	18
M					30	30	28	28	26	26	24	24
N					13½	13½	13½	13½	13½	13½	13½	13½
O					29½	29½	26½	26½	23½	23½	20½	20½
P					13	11½	13½	12	15	13½	13½	14½
Q					26	24½	24½	23	24½	23	20½	21
R					47½	44	44½	40½	45	41½	38	34
S					24	22½	22½	21	24	22½	21	22
T					9	9	9	9	9	9	9	9
U					12	12	11	11	10	10	9	9
V					13½	13½	13½	13½	13½	13½	13½	13½
W					8	8	8	8	8	8	8	8
Boiler heating surface, sq.ft	2,150	1,940	2,050	1,840	1,490	1,330	1,170	1,040	1,010	900	720	630
Grate surface, sq.ft	45½	42	42¼	39	36	33	30½	27½	27½	25	20½	18
Bridge wall retort area, sq.in. each	820	756	761	702	648	594	544½	495	495	450	364½	324
Area between bridge wall and def. arch, sq.in	2,448	2,448	2,040	2,040	1,770	1,770	1,484	1,484	1,326	1,326	984	984
Area under def. arch, sq.in	3,280	3,024	3,041	2,808	2,592	2,376	2,177	1,979	1,979	1,800	1,457	1,296
Number of steam jets					6	6	5	5	4	4	4	4

of agreeable conditions for the performance of labor and the financial benefit derived therefrom, but a major portion of the old boiler rooms are about as pleasant to work in as a dungeon cell. In fact, we have had several cases wherein not enough air was being admitted to the boiler room to supply the oxygen necessary to the burning of the coal. After the owner was compelled to install additional ventilation a marked diminution in the amount of smoke made was noted and more cheerful co-operation from the fireman obtained.

The construction of the "Plate 1" furnace is shown in the illustration. The dimensions of the gas passages were carefully determined by practical test. When this construction is followed it invariably results in the saving of coal and a pronounced lessening in the amount of smoke. The minimum distance from the grate to the shell for boilers of 1,500 sq.ft. of heating surface or less is 36 in.; this distance is required, but a greater distance, up to 60 in., is recommended.

Twenty-five per cent of the grate area is required over the bridge wall through the twin arches, 37 per cent of the grate area between the bridge wall and deflection arch through the piers, and 50 per cent of the grate area under the deflection arch. The arches and piers should all be of firebrick construction.

It will be seen that there is a positive right-angle deflection of the path of the gas travel; the pier and arches over the bridge wall split the gases, the piers between the bridge wall and deflection arch again divide them, and when the gases strike the deflection arch they must make a positive right-angle change of direction, thus bringing the air and gases well-mixed in contact with refractory material, which tends to hold up the temperature. The pier in front of the blowoff is required


Section Through C-C
Section Through B-B
Section Through A-A
Section D-D
Enlarged Section X-X
3" cap with 5/32" hole
3/8" steam pipe
2" air pipe
3" steam header
3" header
2"x2"x2" tee
Furnace width
Connect to high pressure steam main
Quick opening steam valve which must be supplied with an automatic device for closing same, and having an adjustable range of from 2 to 7 minutes
25% of grate area over bridge wall through twin arches.
37% of grate area between bridge wall and deflection arch through piers.
50% of grate area under deflection arch.

Longitudinal and cross-sections of furnace construction

The special furnace work shown here is adapted to a single- or to a two-ring boiler only. Where three-ring boilers are installed the front ends of twin arches and the 4½-in. wing wall must be corbeled out and carried up against shell in such a manner as will thoroughly protect the front girth seam of middle ring from any fire action.

by state law, and further assists in the mixing process.

A detail of the steam-air jet construction is shown. It will be noted that the line of air injection should strike no higher than the rear of the grate, as, obviously, a strong furnace draft will tend to lift the air and gases over the bridge wall without proper mixture. One 2-in. steam-air jet is required for each 250 sq.ft. of heating surface. The jets are spaced about 8 in. from each side wall, with equal divisions between, the number required being shown in the table.

This type of furnace has been found to be superior to any other hand-fired type for horizontal return-tubular boilers. There are hundreds of them in this city in satisfactory use, all contributing their quota to the prevention of smoke and the conservation of coal.

GORDON D. ROWE,
Cincinnati, Ohio. *Chief Smoke Inspector.*

Vibration in Steam Turbines

ONE of the causes of vibration in turbine-generator sets is wear of the claw coupling between the turbine and generator. This allows it to become radially displaced and causes vibration when running. In one instance where a turbine set was found to vibrate, the flexible coupling showed signs of hammering. The clearance between the faces had increased considerably and had developed shoulders nearly $\frac{1}{16}$ in. high. After the shoulders were removed and the coupling adjusted, the unit ran without vibration.

When vibration is present the only way to eliminate it is to remove the cause, but where it persists and no fault can be found, the running of the machine can often be improved by filling the bed plate with concrete and grouting it down solidly to the foundation. Reducing the clearance of the shaft in its bearings to a minimum consistent with cool running is also effective, the usual running clearances being 0.001 in. for each inch of the shaft diameter.

Another trouble that may occur is distortion of the turbine casing through the expansion and contraction of the connected steam and exhaust piping. This makes expansion joints or expansion bends necessary in the pipe. When expansion joints are used they must be properly packed and must have sufficient capacity to take up any movement of the pipe, so that there is no pull on the turbine casing.

In one instance the labyrinth packing at the low-pressure end of a large turbine failed through the distortion of the rigid piping connecting the turbine to the condenser. After this mishap the rigid piping was replaced by a flexible connection and there was no further trouble. In another instance, the labyrinth packing at the high-pressure end of a turbine failed, due to the pull on the casing caused by the rigid bracing of a steam pipe.

Rapid temperature changes within the turbine must be avoided. A set should be started up slowly, so that the turbine will heat up evenly and excessive stresses will be obviated. Not infrequently, when a turbine is being started, a slight vibration is noticed, which lessens as the turbine warms up. This is generally due to distortion, causing the diaphragm, glands or other parts to touch the rotor spindle slightly. Provided the set is warmed up slowly this initial vibration will do no harm, since it is usually of short duration and disappears entirely when the unit reaches full speed. W. E. WARNER.

Brentford, England.

Practical Phase Sequence Indicator

A SIMPLE sequence indicator that is used by a number of light and power companies is the two-lamp and coil instrument. The connections are Y as shown in Fig. 1. The lamps are 10-watt, of the correct voltage, and the coil is an old potential coil from a 110-volt meter.

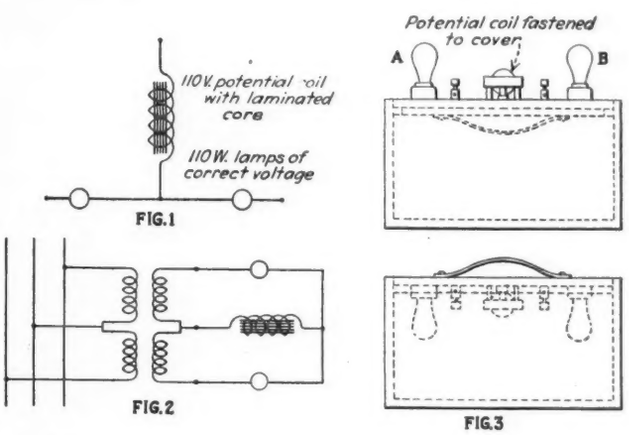
This simple device has many uses around a power plant, partcularly to switchboard electricians and linemen. It is used as a phase-rotation indicator for generators, motors, transformers, meters, etc.

I made a small platform or cover of wood and a box to hold the outfit with its flexible leads and extra lamps and attached simple directions for operation.

When the indicator is to be used the cover is removed from the box and the lamps set upright. The correct lamps are put in the sockets and the flexible leads are connected to the terminals of which the phase rotation is to be determined.

When connected to a three-phase current one of the lamps will burn bright and one dim. If lamp *A* is bright, the phase rotation is said to be *ABC*; while if *C* is bright it indicates *CBA* rotation. A card with these directions is tacked on to the cover. The lamps are lettered to correspond, and colored wire is used for the flexible leads.

In practical use, we will assume that a large group of three-phase motors is to be connected to a new set of transformers. The indicator is first connected to the secondaries of the transformers at the line side of the



Details and connection diagram of phase-rotation indicator

motor's switch and the light that is dim is noted. Then after installing the new transformers the wires are connected to the switch that gives the same indication, and the motors will run in the right direction.

When phasing out generators, use is made of potential transformers as shown in Fig. 2. After connecting the primary to the busbars and noting the dim lamp, the same leads are connected to the generator's terminals, and if the same lamp is dim the phase rotation is the same as that of the busbars. ED SWAN.

Kearney, Neb.

TURBINE SHAFT PACKING should be fitted so that it has a clearance of 0.001 to 0.002 in. per inch of shaft diameter with the machine cold. Metallic packing does not require as much clearance as carbon, since expansion is much greater under high temperature.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

Large Capacity Trap for Steam, Gas and Compressed Air

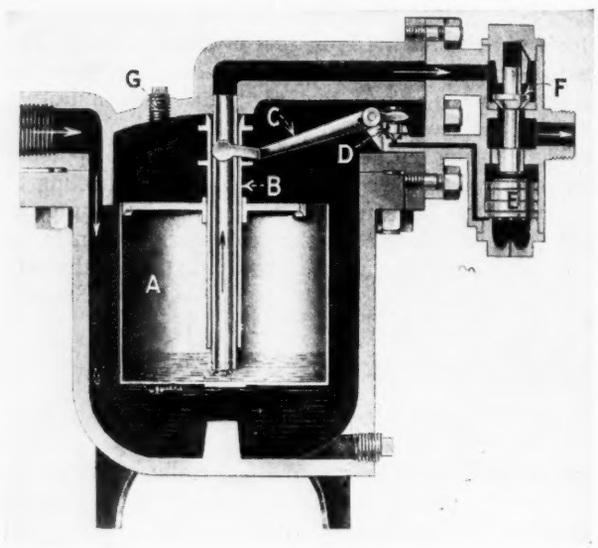
DESIGNED for use with steam, gas or compressed air, and to operate through a wide pressure range without adjustment, the McAuley super-trap illustrated is built for working pressures up to 800 pounds.

The trap body and cover are made of cast iron or cast steel, and all working parts, which are of non-corrosive materials, are assembled on the cover and can be removed from the body as a unit. The discharge unit, containing the wearing parts—the valve and the seat—is flanged to the cover, where it is readily accessible for replacement or repair of the parts.

In operation, the condensate enters the body of the trap as indicated by the arrows. As the body fills, the water overflows into the bucket *A*, until buoyancy is overcome, then the bucket drops, carrying with it the guide pipe *B* and the end of the lever *C*. This movement of the lever opens the pilot valve *D* and admits steam from the top of the trap to the lower side of the piston *E*. As the piston moves upward it pushes the valve *F* full open, permitting the condensate to flow from the bucket to the discharge line. As the bucket is emptied it rises again, closing the pilot valve and cutting off the pressure to the piston. The overpressure then forces the valve *F* to its seat, and the cycle is repeated.

The discharge valve and seat are made extra heavy to allow for reseating, and a cap is provided above the valves to facilitate the work without disturbing other parts of the trap.

When used with compressed air the trap is connected the same as for steam, except that an air connection is made to the cover at the point *G* to provide pressure for operating. The trap, which is put out by the McAuley Automatic Trap Company, Pittsburgh, Pa., is made in six sizes, with inlet pipe connections ranging from ½ to 2½ in.

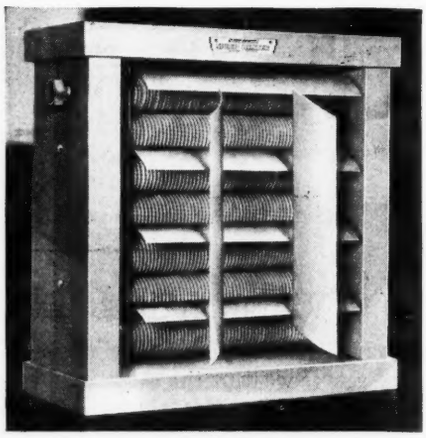


Cross-section of trap showing operating parts

Unit Heaters With Two-Speed Fan Motor

EMPLOYMENT of a two-speed motor to drive the fan, and vertical louvers to break up the air flow and spread it over a wider area are features of the new unit heater brought out by the B. F. Sturtevant Company, Boston, Mass.

The new heater, which is designated the "Speed," is made in three types. In type No. 1 the motor operates at 750 and 950 r.p.m. No. 2 operates at 870 and 1,170 r.p.m. and the No. 3, or cabinet model, at 350 and 750 r.p.m. The No. 1 and No. 2 are designed to be hung from ceilings, beams or walls, cold-rolled steel hangers being supplied with the heater.



View of heater, showing horizontal and vertical louvers

All models of the heaters are equipped with high-pressure Aerofin heating elements suitable for steam pressures up to 250 lb. The elements may also be used with low-pressure steam. The heater is being put out in a wide range of sizes.

Feed-Water Control Varies Water Level Directly With Rating

THE adoption of large boilers having a comparatively small water capacity as compared to the high rates of evaporation at which they are operated, has necessitated important improvement in feed-water regulators to meet the new condition imposed by these high rates of evaporation. The tendency of such high ratings is to cause wide fluctuation in the water level in the boiler drum with the sudden changes in load, and this, in turn, imposes rather severe duty on the feed water control equipment.

Heretofore the general practice in

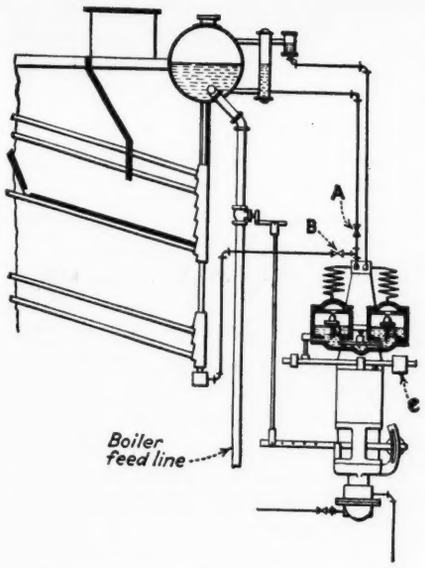


Fig. 1—Regulator connected to give an increased water level with rating

feed-water regulation has been to design the regulator to carry a high water level at light load and a low water level at high ratings. In the feed-water regulator now being put out by the Smoot Engineering Corporation, 136 Liberty St., New York City, the design is based on the theory that a water level gradually increasing with rating is desirable from a regulating point of view, and that it is basically safer from an operating standpoint. To obtain this the regulator is connected with an auxiliary loading force which bears a definite relationship to the boiler rating.

The regulator is essentially an adaptation of the excess-pressure control valve and the operating unit of the combustion control put out by this company. These two units are shown in the accompanying illustration.

The control element for the water-regulating valve consists of two interconnected mercury chambers mounted on knife edges and connected with the steam and water space of the boiler as indicated in the diagram. The bottom of one chamber is connected through a link to a weigh beam, which actuates the regulator power mechanism. The two mercury chambers, with their connection to the boiler, act as a large U-tube, and the difference in weight of mercury from one chamber to the other varies directly with the head of water in the boiler. This difference in weight serves as the control force for the regulator movement. Suitable stop valves of the float-needle type are provided in each chamber to prevent loss of mercury in the event an excessively high differential is encountered.

The auxiliary loading force to give an increasing water level with rating is obtained by utilizing the differential pressure from the boiler drum to the mud drum, to vary the pressure in the connecting lead to one of the mercury chambers. This differential serves to give a loading effect in direct relation to the rating at which the boiler is being operated.

The variation in pressure on one of the mercury chambers is effected by permitting a flow through the connecting lead from the steam drum to the mud drum. Referring to Fig. 1, with valve *A* open and valve *B* closed, the regulator will control for constant level of water, the level being adjusted by the amount of weight *C*. With the valve *A* open and the valve *B* slightly open there is a flow at high ratings from the steam drum toward the mud drum. This tends to lower the pressure on the left-hand chamber, causing the regulator to open the feed valve, which permits the water level to rise and restore the pressure balance in the chambers. More stability is the effect of this control, and it makes possible the utilization of the boiler drum capacity for water storage to its full value.

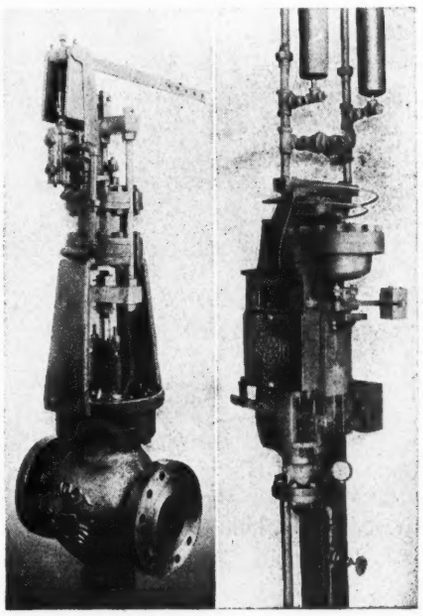
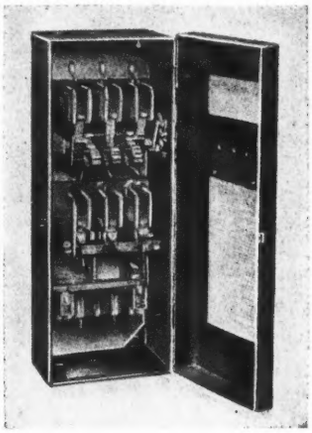


Fig. 2—Feed-water valve and regulator

An important feature of the control unit is the absence of stuffing boxes or pressure-tight bearings, which would affect the sensitiveness of the unit.

Motor Starter With Disconnect Switches and Meter Test Jacks

THE line of standard a.c. across-the-line switches put out by the Allen-Bradley Company, 286 Greenfield Ave., Milwaukee, Wis., is now furnished equipped with hand-operated disconnect switches and meter test jacks, in one cabinet. The disconnect switches are furnished with or without fuse clips, and the meter test jacks permit the motor to be checked for load without opening the cabinet or interfering with the operation of the motor.



Starter equipped with arc shields and magnetic blowouts on disconnect switch

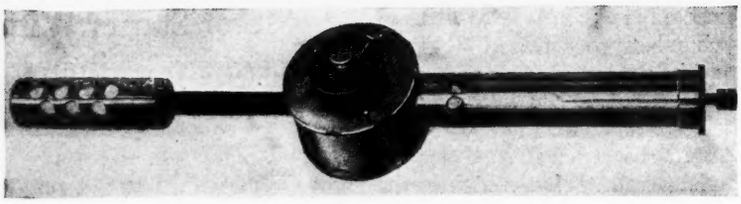
A mechanical interlock between the disconnect switch lever and the cabinet cover makes it impossible to open the cover unless the disconnect switch is open.

The switches are rated up to 10 hp., 110 volts, 30 hp., 220 volts, and 60 hp., 440-550-volts, and are furnished in three forms: Form 1 with push-buttons in the cover, Form 2 for pilot control, and Form 3 with three-way lever switch.

Gas Leak Detector

THE gas leak detector illustrated when plunged into an atmosphere of gas of a density different from air will indicate the presence of the gas whether it be lighter or heavier than air.

The instrument consists, essentially, of a porous clay cylinder connected with a diaphragm by a small tube; and a small incandescent lamp, which serves as the indicator. The diaphragm, by its position, which changes with the density of the gas,



Detector indicates pressure of gases lighter and heavier than air

makes or breaks the lamp circuit.

When the porous cylinder containing air at atmospheric pressure is moved into a region containing a gas, an increase or decrease in pressure within the cylinder takes place, depending upon whether the gas is lighter or heavier than the air. If the gas is lighter the pressure is increased and the circuit is made, while if the gas is heavier the pressure is momentarily decreased and the circuit is broken.

When it is desired to test for a light gas the instrument is adjusted by a screw with a knurled handle, so that a slight movement of the diaphragm will make the circuit; and for a heavy gas the adjustment is made so that a slight movement will break the circuit. Current for the lamp is supplied from a flashlight battery, which, with the lamp, is inclosed in the handle of the instrument. A second contact screw is provided at the end of the handle to break the circuit when the instrument is not in use.

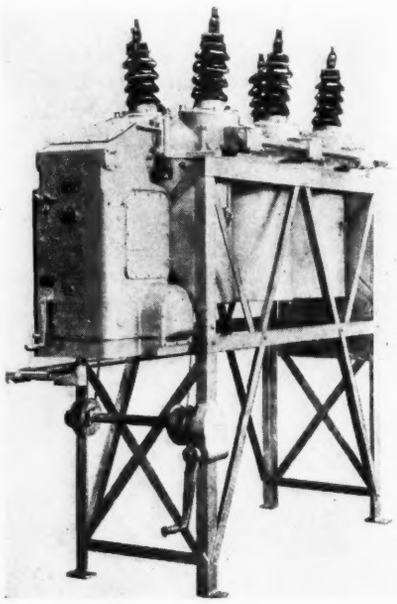
Ability to detect all gases and extreme sensitivity are some of the claims made for the instrument. It is also claimed that the instrument can be set so closely that the carbon dioxide of the human breath will instantly extinguish the light. Also, the detection of an illuminating gas content in air as low as 0.03 per cent can be made.

The detector is put out by the Colonial Supply Company, 217 Water Street, Pittsburgh, Pa.

Oil Circuit Breaker of High Interrupting Capacity

TO THE line of oil circuit breakers put out by the Pacific Electric Manufacturing Corp., 2515 Third St., San Francisco, Calif., has been added two additional sizes, the JC-22, for 25,000 volts, and JC-26, for 37,000 volt operation. Each has an interrupting capacity of 125,000 kilovolt-amperes.

Several of the important features embodied in the JC-17 breaker, which was described in the April 9 number of *Power*, are retained in the new models. These include one cast top member for all three phases, with individual tanks per phase; all operating parts fastened to the one-piece cover; rotary type break, high



Breaker of 125,000-kva. interrupting capacity

operating speed and end or side mounting of control.

The control furnished with the breaker is of the motor wound spring-actuated type, giving high blade speed and positive locking.

Electrode for Steel Plate Welding

A WELDING rod designated No. 18 "Yellow Jacket" for electric arc welding, which it is claimed will weld $\frac{3}{8}$-in. unbeveled plates clear through with one passage of the electrode from one side, is being introduced by the Fusion Welding Corporation, 103rd St. and Torrence Ave., Chicago, Ill.

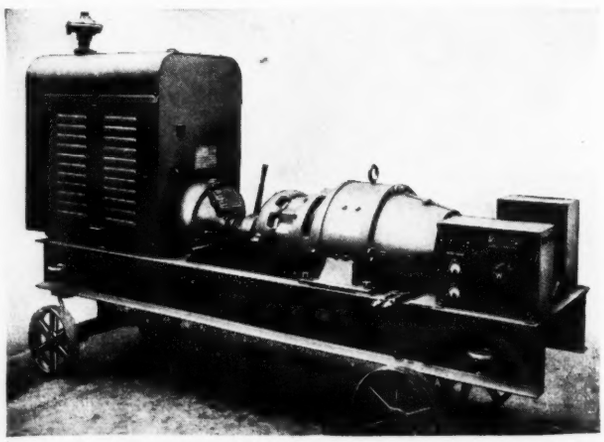
The electrode is especially manufactured for making heavy mild-steel arc welds, such as plate welding on boilers, pipes and tanks. The rod is used in welding plates which are merely butted together, not beveled as in ordinary practice, and the welding is done in one passage of the rod from one side of the piece.

Dual-Drive Welding Unit

TO ROUND out its line of welding equipment the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has introduced the dual drive arc welding unit illustrated.

The unit consists of a standard 300-amp., single-operator welding generator, a 15-hp., alternating-current induction motor and a six-cylinder, 1,800-r.p.m., model P-45 Continental gas engine, all mounted in tandem on a structural steel welded base. The motor operates on 220 volts, but by reconnecting the external motor leads and changing the line-starter coil, it can be used on 440 volts, thereby giving additional flexibility. The welding generator can be driven by either the engine or the motor by simply engaging or disengaging a slip coupling or clutch.

The dual-drive machines can be furnished in all the standard single-operator ratings, stationary or portable.



Welding generator direct connected with induction motor and six-cylinder gasoline engine.

FROM AMONG READERS' PROBLEMS

Conducted by
L. H. MORRISON

INCREASING LOAD ON LOW-PRESSURE CYLINDER—*How can you increase the load that is being carried by the low-pressure cylinder of a cross-compound engine?* R. C.

If the cutoff on the high-pressure cylinder is lengthened, the pressure at the end of the expansion stroke will be higher than before, and consequently the steam entering the receiver and the low-pressure cylinder will be at higher pressure. This would then raise the initial pressure in the low-pressure cylinder, and with its cutoff the same as before, the low-pressure cylinder would develop more power than before.

On the other hand, the high-pressure cylinder would be working against a higher back pressure, and the negative result of this would be greater than the positive result of the longer cutoff in the high-pressure cylinder, so this cylinder's power would be decreased.

BEVEL SEAT OF SAFETY VALVE—*Why do modern pop safety valves have bevel seats?* S.T.

All modern safety valves do not use bevel seats, but the general adoption of this design is based on the greater ease by which they can be made and kept steamtight. In closing, the flat valve would catch any scale resting on the seat, and might leak. The bevel seat has a wiping, or sliding, action, which grinds the scale; so that the tendency of the valve to leak is less.

COILS IN WATER FORECOOLER—*Will it reduce the horsepower per ton of ice to place ammonia coils in a forecooler so that the water for the ice cans can be lowered to 40 deg. from 70 deg. F.?* L.C.R.

The forecooling of the water will permit an increase in the tonnage output of the freezing tank, but the horsepower per ton will not be changed. As the compressor must handle all the ammonia evaporated, its duty is not altered by changing the place of evaporation, provided the gas is taken into the compressor at the same suction pressure.

STEAM-HEATED CYLINDER HEADS—*We have been approached by a firm that desires to place new steam-jacketing heads on the cylinder of a large steam engine, claiming that the engine would show a marked decrease in steam consumption.* E. VAN C.

Careful tests have revealed that the temperature variation in the cylinder heads is small and that the heads play but a little part in heat transfer. It would seem, then, that only a minor saving could be made by the new heads.

PREVIOUS QUESTION

DISCUSSED BY READERS

THE QUESTION

HOW is the power developed by a direct-current motor affected by a drop in line voltage? For example, a 10-hp. 230-volt, 1,750-r.p.m. compound-wound motor is installed in a mine 1½ miles from the power house. The full-load current of the motor is 39 amp. Under test the motor takes 40 amp. at 150 volts. C.O.L.

IT SEEMS to me that "C.O.L." is emphasizing the wrong part of his problem. He is apparently interested in how the low voltage is affecting the motor. The important thing is: "How is the low voltage affecting the cost of operation?" Assuming the voltage at the power plant to be 240: since it is 150 at the motor, there is a drop of 240 — 150 = 90 volts in the line. As this drop is caused by a 40-amp. load, the wattage loss in the line is 90 × 40 = 3,600, or 3.6 kw. If this condition exists for 8 hr. a day, 300 days a year, the kilowatt-hours loss in the line will be 3.6 × 8 × 300 = 8,640 kw.-hr. At 2c. per kilowatt-hour the line losses cost 8,640 × 0.02 = $172.80 a year.

This cost will vary with the conditions. If the load is continuous and the price of power is 2c. per kilowatt-hour, the cost of the line losses is $631.72 a year. The exact costs can be determined only by someone familiar with all the conditions under which the motor is operating. Then an intelligent effort can be made to correct the difficulty.

The first thing that suggests itself is to increase the size of the line. In the present line the conductors are probably No. 1 or No. 2. Running a second set of conductors in parallel with the present will cut the line drop in half and save one-half of the cost of the losses. Although this will not bring the voltage at the motor up to normal, it will greatly improve conditions and will allow the motor to carry the load on a current well within its rating.

If the system can be operated with a ground on one side, and if the motor is now supplied over a complete copper line, it may be possible to put the two lines in parallel on one side of the circuit and use the ground for the other. This can be done only with a low-resistance ground, such as a pipe line. Unless the ground connections are well made and maintained, their resistance may be quite high and defeat the object in mind.

The motor's armature might be rewound for 150 volts. The field coils may be divided into two groups and the groups connected in parallel. To bring the voltage down to 115 across the field coils, a resistance may be connected in series with them. With the motor operating rewound for 150 volts, the field losses, on account of the rheostat, will be higher than they are now, but the armature losses will be less, so that the total motor losses with the new winding will be practically the same as they are now. The line losses will probably be a little less.

Rewinding the machine will be cheaper than increasing the size of the line, and if the motor is used only intermittently, rewinding will probably be the most economical. On the other hand, if operation is continuous, the cost of increasing the size of the line will probably be justified. The foregoing does not take into consideration the effect of the low voltage on production.

Los Angeles, Calif. M. A. WALKER.

THE power that a direct-current motor develops is the product of the current, voltage and efficiency. This product divided by the constant 746 gives the actual horsepower. The efficiency under any abnormal condition will be less than full-load efficiency under normal conditions. The value of 86 per cent would appear to be full-load efficiency at normal voltage. Under existing conditions it is doubtful if the efficiency is even 70 per cent, but assuming this figure, the actual horsepower is $\frac{150 \times 40 \times 0.7}{746} = 5.63$.

The speed of a direct-connected motor varies proportionately with the armature voltage and inversely with the field strength, following a field-strength-speed curve which will be peculiar for the particular motor. In the case under reference, the motor is compound wound, and it is not stated whether the compounding is heavy, so as to approach series characteristics, as in a

capstan or hoist motor; or light, so as to give a drooping load-speed curve, as in motors used with flywheel machines. For the former conditions, as the current is approximately normal full-load amperes, the series field will be about normal, and the reduction in speed of the motor will be nearly proportional to the reduction in terminal voltage. In the latter case, the shunt field will control. As this will be less than normal, the reduction in field strength will partly offset the reduction in armature voltage, and the speed of the motor will be higher than in the former case. The motor designer would be the only one able to predict the exact speed to be expected under the questioner's conditions.

It would not be advisable to install a smaller, standard motor. Although mechanically the motor is unnecessarily large, a smaller motor would not have the current-carrying capacity, and the windings would overheat and ultimately burn out.

C. E. Olive,
Chief Engineer,
Canadian Celanese Ltd.
Drummondville, Que.

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SINCE the power developed by a direct-current motor expressed in watts is the product of the current, terminal voltage, and efficiency, a drop in line voltage will cause a proportional loss in developed power.

The power developed by the motor under discussion is 6.9 hp. as calculated from the given test data and assuming 86 per cent efficiency. To carry this load on reduced voltage, a proportional increase in current is necessary, which, in this case, has reached the full-load rating on the motor. To carry a greater load or the same load on a lower voltage demands a higher current consumption, and will cause the machine to overheat.

A motor should be selected for economy at normal loads, but it must also be able to carry the maximum expected load under the most unfavorable conditions without dangerously overheating. Because this unfavorable condition of reduced line voltage must be reckoned with, and since the present motor is now running at its rating with respect to current, it is not advisable to install a smaller motor.

Detroit, Mich. A. W. Thorson.

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THE power that the motor will develop when operating on 150 volts will depend upon two main factors: (1) The degree of magnetic field saturation under normal conditions, and (2) the amount of compounding. Unless these two factors are known, I do not believe any answer obtained otherwise will be very accurate.

The motor takes 39 amp. at 230 volts, making it less than 83.2 per cent efficient, instead of 86 per cent as stated. The permissible current input at 150 volts should be slightly less than 39 amp., on account of the reduced speed, which would decrease the ventilation of the machine. It is advisable to operate the motor approximately 10 per cent below normal current, making the full-load current 35 amp. at 150 volts.

The input of the motor would be $150 \times 35 = 5{,}250$ watts. Not knowing the factors previously mentioned, the motor efficiency on the 150 volts may be assumed to be between 70 and 78 per cent, hence the motor will develop from 5 to 5.5 hp. These figures are dependent upon previous performance characteristics under normal voltage.

Operating a shunt or compound motor on such reduced voltage would be poor practice from the standpoint of efficiency. Increased armature reaction, speed variation, and general performance are bound to give trouble under variable loads and sudden overloads. I recall several installations having shunt and compound motors operating with over-excited shunt fields, that is, the iron was worked at a high magnetic density when cold, so as to compensate for the decrease in the shunt-field current when the machine reached operating temperature, thereby maintaining fairly constant speed throughout the heat range. That class of motors showed better performance under low voltage than machines working at lower magnetic densities. I believe the remedy for "C.O.L.'s" case should be considered from a different angle. It is a known fact that the trouble is not in the motor, but in the power lines supplying the motor. Why not turn to the task of compensating for the voltage drop in the long power lines?

I had a similar case, where a shop was located some two miles from the main generating plant. The power was supplied by a 240-volt, two-wire direct-current line. Line losses were quite troublesome. In some cases we were able to improve production by replacing the shunt or compound motors with series motors; however, the number of machines replaced was small, due to the speed characteristics of the series motor. Changing the motors did not improve the lighting, so we turned to a general reconditioning of the power and lighting lines. Due to the limited appropriation for this temporary project, we were compelled to utilize machinery and apparatus from our reserve stock, which was somewhat lacking in quantity. Deciding upon the booster method as the most economical under those conditions, we placed a 110-volt shunt-wound booster on the power line at the power house. The shunt field circuit of the machine was connected through a field rheostat of suitable resistance so as to be separately excited from the main busbars. The armature circuit was connected in series with one leg of the long power line and the polarity of the booster made additive. The machine was belted to the engine flywheel of the main generator.

Using the shunt-wound booster required readjustment of the field rheostat as the load varied. However, we were able to check up on the power demand as well as the behavior of the booster. Later the shunt-field coils were replaced with series coils having the proper number of turns to vary the voltage on the booster just enough to compensate for the voltage drop in the power line. The voltage regulation of the series booster was automatically controlled by the power demand at the other end of the line.

Alfred F. Dressler.
New York City.

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THE 10-hp. 230-volt motor operating at full load and full voltage would require $\frac{230 \times 39}{1{,}000} = 8.97$ kw. Operating at 150 volts and drawing 40 amp., it would take $\frac{150 \times 40}{1{,}000} = 6$ kw. The power developed is $\frac{6{,}000 \times 0.86}{746} = 6.9$ hp.

A smaller motor should not be used, as the heating of the motor is proportional to the amperage and not to the horsepower output. The 10-hp. motor under these conditions was actually very slightly overloaded, as it was consuming one ampere more than its normal rating, although the horsepower output was only 69 per cent of rating. The power output of a motor of this type operating at reduced voltage would be approximately in proportion to the voltage, or in other words, if the amperage is normal and the voltage is only two-thirds of normal, then the horsepower output will be only about two-thirds of normal.

Kenneth C. Monroe,
Plant Engineer,
Bridgeport Brass Company.
Bridgeport, Conn.

A Question for Our Readers

AFTER rewinding a 75-hp. 2,500-r.p.m. shunt motor and putting it into service, difficulty was experienced with the bands heating. There are five bands made of steel wire equally spaced along the length of the armature, each band being about 1½ in. wide There are sheet-copper clips on the bands at eight equally distant points around the armature, and the bands are soldered to form a smooth ring. The air gap is ample, so that the bands do not touch the polepieces, and there are no faults in the armature's winding. The bands get so hot that they throw the solder and have come loose. I would like to know how to overcome this difficulty? D. L.

Suitable answers from readers will be paid for and published in the Dec. 17 issue.

Practical Refrigerating Engineers Meet at Pittsburgh

THE twentieth annual convention of the National Association of Practical Refrigerating Engineers, held in Pittsburgh, Pa., from Nov. 4 to Nov. 8, was an outstanding event in the history of this organization. The attendance was up to the average, and the papers were of unusual merit.

The convention was opened on Monday, Nov. 4, with registration of delegates, address of welcome by the mayor, and a response by G. A. Pardee, first vice-president of the organization. After the appointment of several committees and the reports of the officers, the delegates turned to the technical portion of the program.

The introductory paper was on "Lubrication for Refrigerating Plants," by J. L. Rossenmiller, York Oil & Chemical Company, York, Pa. He pointed out that the three oil characteristics of vital concern to the refrigerating engineer are the viscosity, the pour point and the flash point. To these he added the carbon-residue percentage, which he held should not exceed 5 per cent. The pour point, or the temperature at which the oil is so thick it will not flow, must be known if proper lubrication of an ammonia compressor is to be obtained. This temperature should be from —15 to —20 deg. F. The flash point should range from 330 to 340 deg. F. and the viscosity should be 180 to 200 sec. Saybolt at 100 deg. F.

The author called particular attention to the fact that the viscosity changes with a change in temperature, but that as regards any two oils the rates of viscosity change are not similar. For example, he cited three oils, one a Pennsylvania, the second a Texas and the third a California oil. These show the following viscosity characteristics:

	Pa.	Texas	California
Viscosity at 100 deg. F., sec.	220	300	400
Viscosity at 212 deg. F., sec.	63	48	78

Consequently, the viscosity at the operating temperatures should always be investigated when a new oil is purchased.

In inclosed-crankcase compressors in which a splash oiling system is used, the oil should not have a tendency to permanently emulsify with water, for an emulsion will stop up the oil lines and interfere with lubricating the bearings. To eliminate this danger the oil should be put through a clarifier.

Discussion on Condensers

"Vertical Shell-and-Tube-Condensers" was the subject of a paper presented by F. R. Zumbro, chief engineer, Frick Company. The author outlined the general construction of the shell-and-tube condenser. The diameter of the shell ranges from 16 to 68 in., with a tube length of 10 to 18 ft. Joints are welded both by the electrical and hammer processes. It was claimed by the author that the heat transfer rate is equal to that of the atmospheric pipe type and the water loss by evaporation is no greater. It has the advantage of permitting equal distribution of the water, regardless of the amount flowing. The water velocity is constant at all loads, quite different from the action in a double-pipe condenser. Each tube will handle up to 3 gal. per minute. Each ton of plant capacity requires from 10 to 17 sq.ft. of condenser surface. On the other hand, the loss when the steel was placed in a 10 per cent still brine was 14 grams, and in an agitated 10 per cent brine the loss rose to 96 grams.

It is a matter of observation that the corrosion is least when the liquid is at the neutral point, which lies between the pH valves of 7.2 and 8.

When a zinc-coated ice can is first placed in service, it is clean and bright. The brine should have a pH value of about 8. In a short time the action of the brine causes the formation of a thin coating of zinc hydrate. This hydrate changes to zinc oxide and zinc carbonate when the can is exposed to the air when pulling the ice. This is highly protective to the ice can, and to prevent its removal the brine pH value should be raised to as much as 10.

Brine Tank Corrosion

While many so-called corrosion preventives fail to do all claimed for them, there is no doubt that neutral sodium chromate, used at the rate of 150 lb. per 1,000 cu.ft. of brine tank volume, will stop corrosion. The neutral chromate is recommended in preference to the dichromate, as it can be obtained at any supply house and does not need to be neutralized by caustic soda. No trouble will be experienced, the speaker stated, from "chromium itch" if the workman washes his hands several time a day.

To stop corrosion on brine- and water-piping surfaces, the pipe should be brushed free of scale, after which a paint made up of 50 per cent red lead and 50 per cent lead chromate should be applied. A top cooling of any waterproof paint can be added if desired.

The next paper offered was on "Research," presented by S. M. Kintner, of the Westinghouse Electric and Manufacturing Company, Pittsburgh. This covered the general need and scope of the research work carried on at the Westinghouse works. The delegates evidenced the greatest interest in some experiments in liquid air.

At the Tuesday afternoon session "Modern Low-Side Evaporating Surfaces" was discussed by Charles M. Gilbert, of the American Radiator Company, Chicago. This paper dealt exclusively with cast-iron section design. The use of such sections, which are similar to the ordinary heating radiator, eliminates the necessity of an accumulator. The pressure drop through the evaporating system is much less than if the usual long pipe coils are employed. This reduction exerts a favorable influence over the compressor horsepower and the large disengagement surface per unit of heat absorption surface reduces the likelihood of liquid slugs reaching the compressor. Under service conditions a radiator surface of 80 sq.ft. is equal in heat-removing capacity to 100 sq.ft. of pipe coil surface.

With a brine-circulating system the saving in pumping power averages 20 per cent if the radiator sections are used, due to the reduced frictional resistance of the short vertical tubes. When the sections are to be immersed in brine, the vertical tubes are provided with fins to increase the surface.

The weight of the ammonia charge per square foot of exposed surface is high, 4.5 lb. per 6 sq.ft. section being a common charge.

Need of Records Stressed

"The Advantages of Indicating and Recording Instruments" was the subject of the paper of George A. Horne, vice-president, Merchants Refrigerating Company, New York City. He pointed out that 20 years ago the simple steam plant had few indicating and no recording instruments, other than a steam gage and possibly a feed-water thermometer. Little else was needed, for the cost of fuel was so low that efficiency was not imperative. With higher coal prices, instruments to reveal the performance of the generating equipment became essential. Consequently, today the steam plant is fully equipped with instruments of varied types and for many uses.

Instruments, so the speaker declared, are equally necessary in the refrigerating plant if anything like an acceptable efficiency is to be obtained. The section and discharge pressures and temperatures should be recorded by suitable instruments, and brine temperature, air temperature and condenser water flow should be given a permanent record. By installing an ammonia meter, preferably of the Venturi type, enough data are obtainable to permit a test to be conducted at any time. The speaker emphasized the importance of using the steam engine indicator to show the compressor-cylinder events. Without a periodic plotting of diagrams leaky valves and piston rings cannot be discovered until the plant operation is seriously impaired.

Wednesday morning Prof. F. G. Baender, Mechanical Engineering Department, Oregon Agricultural College, presented a paper on "Diesel Engines and Operating Characteristics." The author explained in a simple, concise manner the various engine cycles and the operating procedures the engineer must follow to insure reliability and continuity of operation.

The second paper of this session was "A Study of the Multi-Effect System," by Harry Sloan, Vilter Manufacturing Company. Mr. Sloan showed graphically and analytically the economic gain obtainable by multi-effect compression. If the ammonia coming from the receiver is reduced to a pressure somewhat above the evaporating pressure, by passing into a "flash" tank, about 16

per cent of the liquid will evaporate, and in so doing the remainder of the liquid is precooled before entering the evaporating coils. The flash gas is passed to the compressor, into which it flows after the cylinder is charged with gas from the evaporating coils. Or, where two coil temperatures are carried, the same compressor arrangement can be used. This is the multi-effect compression system invented by Gardner Vorhees years ago and just now coming into general use. Using two suction temperatures, of —2 and +24 deg. F., the speaker showed an increase in compressor capacity of over 40 per cent and a reduction in power per ton of 8 per cent.

On Wednesday afternoon the delegates were guests of the Westinghouse Electric & Manufacturing Company, and spent several hours inspecting this company's large factory at East Pittsburgh.

Thursday, G. E. Hulse, New Haven, Conn., gave a paper on "Silica Gel Refrigeration." This covered the general plan of the application of silica gel to an absorption refrigerating system for railroad cars. A second paper at this session was that of O. P. Heller, Creamey Package Co., on "Dairy Refrigeration," which outlined the general requirements of a dairy.

On Thursday afternoon new officers were elected as follows: President, George A. Pardee, Louisville; first vice-president, W. C. Reinhard, Houston, Texas; second vice-president, James S. Spalding, Memphis, Tenn.; secretary, E. H. Fox, Chicago; treasurer, G. E. Chamberlain, St. Louis. No decision was made as to where the 1930 convention will be held. This will be decided by the directors at a later date.

Research in Boiler Feed-Water Purification

By A. A. Potter

Dean of the Schools of Engineering and Director, Engineering Experiment Station, Purdue University

RESEARCH in boiler feed-water purification has been concerned mainly with the causes of cracks in boiler steel. The term "caustic embrittlement" has been applied to a peculiar type of intercrystalline cracking of boiler steel occurring while in service. Such failures are indicated by fine cracks in the metal, which occur always below the water line.

Researches in Caustic Embrittlement—The most extensive studies on this subject have been carried on by the engineering experiment station of the University of Illinois from 1912 to 1928. The findings are reported in three bulletins published by that institution.

Bulletin No. 94 of the engineering experiment station of the University of Illinois, entitled "The Embrittling Action of Sodium Hydroxide on Soft Steel," published in 1917, indicates that the embrittling effect of sodium hydroxide on steel is due to the evolution of hydrogen and the absorption by the steel of hydrogen in the nascent state. Magnesium sulphate and sulphuric acid were found helpful in counteracting excessive alkalinity.

Bulletins 155 (1926) and 177 (1928) of the engineering experiment station of the University of Illinois report a continuation of this study in co-operation with the Utilities Research Commission of Chicago, Ill. Bulletin No. 155, on "The Cause and Prevention of Embrittlement of Boiler Plates," discusses three types of cracks that may occur in boiler plates: corrosion cracks, fatigue cracks and embrittlement cracks. Corrosion cracks are due to the direct corrosion of the metal, a condition which seldom occurs with feed water that is alkaline in character. Fatigue cracks follow a course independent of the grain boundaries of the metal; while embrittlement cracks follow the grain boundaries. The conclusions of this study are that embrittlement of boiler plate is caused by the combined action of stress and chemical attack. The presence of sodium sulphate in the feed water and of undecomposed sodium carbonate tends to retard the embrittling effect of carbonate waters. Methods for introducing sulphates in boiler waters have been worked out to the point of practical application.

Bulletin No. 177, entitled "Embrittlement of Boiler Plate," includes a study of a great variety of plants with boiler pressures varying from 30 to 250 lb. In every case where cracks in boiler plate occurred the feed water failed to meet the recommendations of the A.S.M.E. Boiler Code as to sodium carbonate-sodium sulphate ratio. This ratio varies with the boiler pressure and has been recommended in the A.S.M.E. Boiler Code (1926) as 1 to 1 for pressures up to 150 lb.; 1 to 2 for 150 to 250 lb.; 1 to 3 for pressures above 250 lb. The studies in Bulletin No. 177 corroborate the findings in Bulletin No. 155 that embrittlement is caused by the combined action of stress and chemical attack; that caustic embrittlement is found in boilers where there exists a high concentration of caustic soda; that no steel suitable for boiler plate is resistant to the embrittling action of caustic soda; and that the presence of a small amount of phosphate will inhibit caustic embrittlement.

Embrittlement-prevention methods for boilers that are the result of the University of Illinois tests are discussed in an article by F. G. Straub in *Power Plant Engineering* 33 (1929) and in *Chemical Abstracts* 23, 9, 2231, May 10, 1929. Tannate and acetate are helpful in inhibiting embrittlement.

In the transaction of the American Society for Steel Treating, Volume V, No. 4, a paper on the "Intercrystalline Fracture of Steel" reports studies carried on at the Massachusetts Institute of Technology. The conclusions of this investigation are that oxides and sulphides are two of the prime factors in caustic embrittlement. The action of hydrogen in causing embrittlement is explained.

Some European authorities do not agree that boiler cracking, apart from corrosion cracking, is due to any chemical agents found in the boiler. They state that embrittlement is due to the inherent qualities of the metal making up the boiler plate. A paper before the meeting of the Iron and Steel Institute, in London, in 1918, of studies made by Walter Rosenhaim and D. Hanson, of the Physical Laboratory of London, show that cold-working of boiler plates either previous to or during the manufacture of the boiler, with low-temperature annealing, will make steel brittle. Experiments by Bussum, of Holland, attribute boiler metal cracks at seams to fatigue of the metal from too frequent alterations of pressures in the boilers and also to intermittent periods of operation. An article in *Power*, June 18, 1929, by Messrs. Straub, Hopkins and Whitney on "The Effect of Cold-Working on Boiler Drums," presents the results of an experimental study indicating that caustic embrittlement due to high carbonate alkalinity occurs only where fabrication has set up internal stresses in the metal.

Investigation of Corrosion—The cause of corrosion is often traced to make-up water that liberates oxygen and carbon dioxide from the "activated sludge" contained in it. The oxygen and carbon dioxide may be removed by heating the make-up water to 200 deg. F. or more. The report of the Prime Movers Committee of the National Electric Light Association for 1922 relates a case of corrosion of steel tube economizers from a high concentration of oxygen and carbon dioxide in the feed water, which was improved by heating the make-up water.

The 1924 report of the same committee records experiments carried on in France with de-oxygenation of water by passing it through iron shavings.

Priming and Foaming—The *Journal for Industrial Engineering Chemistry*, Volume 16, 1924, includes in an article by C. W. Foulk a report of studies of "Foaming of Boiler Water" carried on at the Ohio State University. The conclusion of this investigation is that foaming will occur if the concentration of the sodium salts becomes high.

The *Journal for Industrial Chemical Engineering*, Volume 17, 1925, describes an investigation which was carried on by E. B. Millard and T. E. Mattson at the Massachusetts Institute of Technology on "Surface Tension as a Factor in Priming of Steam Boilers."

A.S.M.E. Joint Research Committee on Boiler Feed-Water Studies.—Through this committee, six national technical organizations are co-operating actively in the study of various processes employed in the purification of feed water. Eighteen reports have been made by this committee, including exhaustive bibliographies on boiler feed water.

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

*Spot * News*

WHAT IS BELIEVED *to be a new world's record for a single hour's output by any power company was made the week of Oct. 26 by the Niagara Hudson Power Corporation, when it was called upon to supply a demand of* 1,075,000 *kw. This marked the second time within the month that the Niagara Hudson system exceeded the* 1,000,000-*kw. mark, a peak of* 1,064,000 *kw. having been reached the week of Oct.* 5.

* * *

AS A RETURN COMPLIMENT *to the enjoyable western trip taken by Eastern members of the American Society of Mechanical Engineers last summer, Western members will tour the East next year in connection with the* 50*th anniversary of the society.*

* * *

CONSTRUCTION *of a* 125,000-*hp. hydro-electric plant and large irrigation reservoirs on Deer and Diamond Creeks is a part of the program for the development of Utah's water resources recently presented to the state water storage commission by the Strawberry Water Users' Association.*

* * *

ARIZONA *has definitely decided to carry the Boulder Dam controversy to the courts, according to a formal statement issued by the Arizona Colorado River Commission. The proposed project is obviously designed for the benefit of southern California, the statement says.*

* * *

FUEL *consumed in the production of electricity by public utility plants throughout the country in July, August and September of the current year totaled* 11,343,275 *short tons of coal,* 2,337,459 *barrels of fuel oil, and* 29,756,-534,000 *cu.ft. of natural gas, according to statistics made public recently by the Department of the Interior.*

* * *

THE PETITION *filed by the Pacific Gas & Electric Company with the California Railroad Commission for rehearing of the commission's decision fixing the valuation of the company's properties within the city and county of San Francisco at* $28,500,000, *when the company claimed* $60,000,000, *has been denied without comment.*

World Engineering Congress Acclaimed a Success by Those Attending

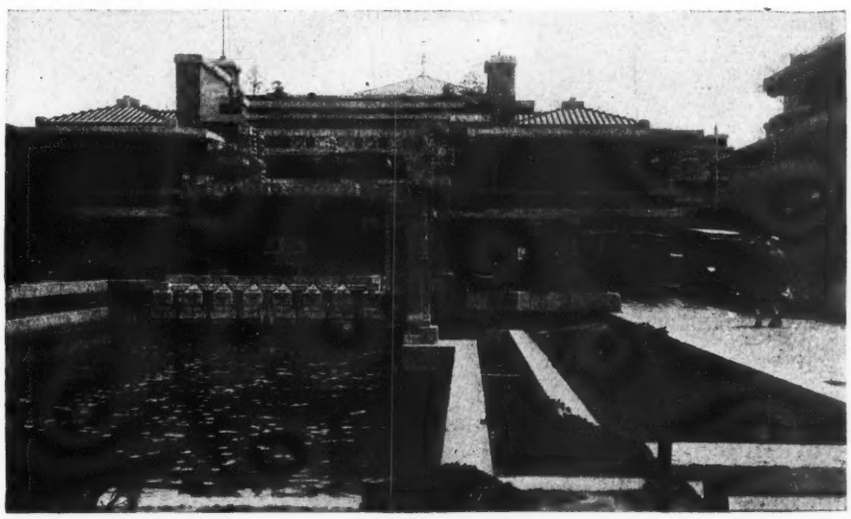
Engineering Placed in International Basis Through Exchange of Many Papers—Japanese Hospitality and Lavish Entertainment Add to Enjoyment of Delegates—World Power Conference Holds Simultaneous Sectional Meeting

TWENTY-SIX countries were represented at the World Engineering Congress, held in Tokio, Japan, Oct. 29 to Nov. 7. It was opened impressively in the new Municipal Building by Prince Chichibu, while Premier Hamaguchi, Baron Furuichi and representatives of other nations were in attendance. On this occasion emphasis was laid by all present on the marvelous industrial progress of Japan during the short period of 50 years since Perry's advent there, and hope was expressed that the experience gained from other countries would prevent injury to the country's natural beauties and age-old culture in the pursuit of future developments. Speakers from all nations stressed the part played by engineering in the advancement, welfare and economic progress of all countries, the value of the engineering profession being recognized now as never before in official circles.

Beginning with the suggestion fathered by Dr. Elmer Sperry and approved by President Hoover while Secretary of Commerce, this congress grew into the greatest conference for the exchange of engineering education on all phases of modern industry, covering the past and future prospects under most varied conditions. Steam from volcanic heat and electric power generation by windmills are possibilities that were touched. Steam is still favored for locomotives, but the Diesel type is increasing, since the turbine type is still experimental, although there is strong rivalry between Diesels and turbines powered by powdered fuel. The advantages of high voltage and superpower interchange were discussed, with the hope for an international steam table and a standard form of power-utilization statistics. Water storage for power, flood mitigation and irrigation were carefully considered in the light of American experience.

The World Engineering Congress included, in effect, the sectional meeting of the World Power Conference, which went on at the same time. Although the organizations were under separate executive committees and maintained their own offices, Baron Koi Furuichi was president of both. Many of the delegates were members of both conferences. The social functions and excursions were largely joint affairs.

The development, transmission, and use of power played a dominant part in the World Engineering Congress discussions as well as its obvious place



Imperial Hotel, Tokio, headquarters of the World Power Conference

in those of the power conference. Japan produces more than half of her power by hydro installations, due to the natural advantage of high runoff in a mountainous country; therefore Japanese papers were cast largely from a hydraulic viewpoint. Matsataka Taxawa, director of the Dengyosha Prime Mover Works in Tokyo, gave a good picture of turbine requirements in Japan as they affect both the Japanese industry and the imports from America and Europe. Chuzo Mori, of the Tokyo Electric Light Company, gave a general review of the hydro-electric power system of his nation. Japan possesses the third largest hydro-plant in the world, which, with many other power plants and stations, was among the high spots of the excursion program.

Propellor turbines in Japan were described by Bunkichi Tanaka of Tokyo. Keizaburo Hashimoto, president of the Nippon Oil Company, spoke on the transition of oil consumption for power use in his country. Other sources of power, such as the wind and tides, were also covered by Japanese papers.

Diesel engines occupied a prominent part of the sessions. Mitsukichi Ino, of the Mitsubishi Shipbuilding & Engineering Company, gave his views on the future of Diesels in Japan.

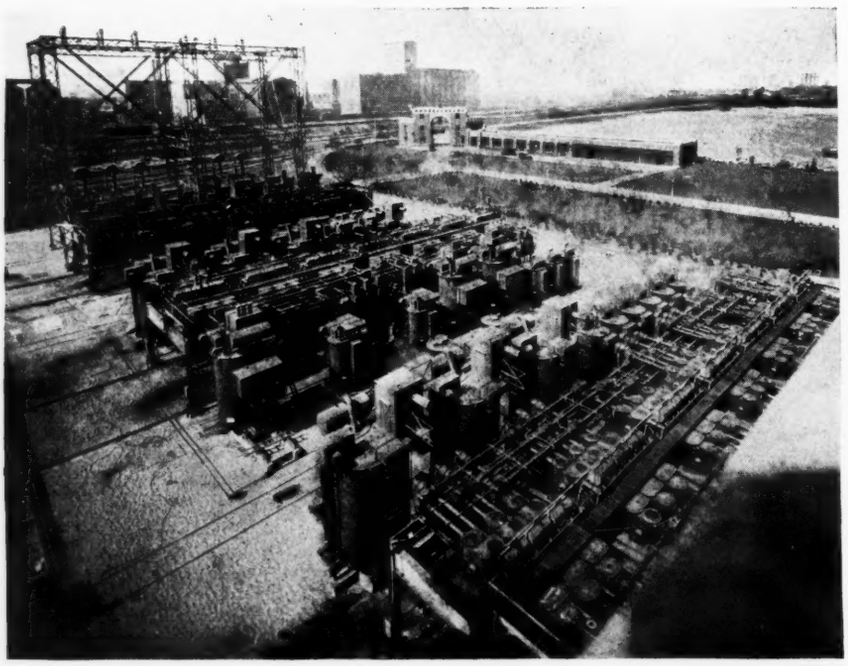
Several German papers were presented among which was that on airless fuel injection, by Dr. Ing. G. Eichelberg, R. W. Allen, of London, spoke on Diesel auxiliary generating machinery and also on surface condensing and feed-water heating plants, in which he has made some interesting developments. Prince Piero Ginori Conti, of Italy, gave an account of his experiments in the harnessing of volcanic heat for power purposes. So far, he said, the main developments have been through the use of natural steam and hot water, but more promising results from limited types of volcanic phenomena are to be foreseen.

In a paper on sewage disposal, John D. Watson, of England, predicted the more extensive use of sewer gas for power generation as a profitable by-product of modern municipal treatment plants. The railroad phase of the power industry was covered in some detail, the possibility of turbine-driven locomotives being among the outstanding points of interest.

A dinner given by the American delegates to Japanese engineers was attended by Prince and Princess Chichibu, with the many notables with their wives taxing the hotel capacity. Dr. Sperry was toastmaster. Addresses were made by Baron Furuichi, Baron Takuma, F. B. Jewett, George Otis Smith.

At a special dinner held by the A.S.M.E. an honorary membership was bestowed on Viscount Shibusawa and the Holley Gold Medal was presented to Baron Shiba. Dr. Grunsky, representing the A.I.E.E., bestowed an honorary membership on Baron Furuichi, president of the world congress.

Chicago was mentioned as the next meeting place of the Congress, the date to coincide with the opening of the World's Fair there in 1933.



NO OPEN-WIRE circuits are used in the outdoor switch-yard at the State Line station, Chicago. Metal-clad isolated-phase construction is employed, each bus being in an oil-filled bronze pipe and the connections in oil-filled bronze junction boxes. No disconnects are used, the circuit breakers being disconnected by lowering with an elevator. Transformers are integral with their respective transmission lines.

News of Canada

New Steam Unit Tested—Initial Unit Starts Operation at Bow River—Back River Project Producing—B. C. Power Plans $50,000,000 Development—Lois River Project Launched

TESTS are being carried out at the New Brunswick Power Company's plant on a new 7,500 kva. steam-electric unit. It is notable that the boiler and turbine with their auxiliaries occupy the space originally housing six old hand-fired boilers. Utilizing pulverized coal, the boiler is designed to operate at 440 lb. pressure with 250 deg. of superheat. The boiler and its complement of water-cooled furnace, etc., built by Canadian Vickers, of Montreal, is believed to be the largest unit of its kind so far built in Canada.

Calgary Starts Bow River Unit

The first unit of the Calgary Power Company's big hydro-electric development at the junction of the Bow and Ghost Rivers, in the province of Alberta, went into operation on Oct. 23, and is now supplying power to the city of Calgary over the company's lines. The first stage of the Ghost development—representing the largest single undertaking of its kind in Alberta—calls for an initial installation of two units with a combined capacity of 36,000 hp., being part of an ultimate planned installation of 64,000 hp. at the Ghost and neighboring Radnor power sites.

Back River Producing

The first two units of the new power plant of the Montreal Island Power Company, on Back River, have gone into production. The initial delivery of 24,000 hp. is being made to the Montreal Light, Heat & Power Consolidated. The entire plant will eventually consist of ten units of 12,000 hp. each with a maximum capacity of 90,000 hp. under normal conditions. At present only six of these ten units are under construction.

Plan $50,000,000 Program

The annual report of the British Columbia Power Corporation, issued Oct. 15, presages an expenditure of $50,000,000 on power development within the next six years. The $50,000,000 will be spent largely on development of Bridge River, Ruskin and Campbell River hydro-electric projects. The total capacity of Bridge River is estimated in the report as 750,000 hp. In the Ruskin development the ultimate capacity is reckoned at 188,000 hp. and will cost $20,000,000. About 47,000 hp. will be brought into service in about a year.

Lois River Project

The Powell River Company, of British Columbia, will spend $6,000,000 to $8,000,000 on hydro-electric development on Lois River and install another paper-making machine to use the extra power thus provided. At the present time Powell River pulp and paper plant

uses approximately 50,000 hp. generated from the fall of water from Powell Lakes to the sea. The company plans to add a plant on Lois River, 10 miles distant, which will give a further 32,000 hp. About half of this capacity is to be developed within the next year or so.

Largest Single-Shaft Unit Installed by N. Y. Edison

A new 160,000-kw. turbine-generator, the largest single-shaft, single-unit machine in the world, has just been put on the line at the East River generating station of the New York Edison Company in New York City. Costing a total of $12,500,000, the new addition brings the capacity of the station up to 280,000 kw.

Other units of similar capacity have been built recently, but none approaches in size the new East River unit. The other machines are cross-compound. The East River unit has a single generator, which is 60 per cent larger than any other manufactured to date. It is driven by a single shaft, which directly connects it to a tandem-compound steam turbine. The turbine is made up of 24 stages. The buckets in the last stage are 32 in. long, and the linear velocity of their tips is more than 11 miles a minute, or nearly 700 miles an hour. In contrast to the 32-in. buckets, are those in the first stage, which are $1\frac{3}{4}$ in. long.

Three boilers furnish steam to drive the turbine. They are of the double Ladd type and exceed any other boilers in the world in steam-generating capacity. Each has 3.786 tubes, three inches in diameter, and ten drums, the largest drums or headers being 54 in. in diameter. The total length of the tubes in the three boilers is 69 miles. Fired by pulverized coal, the boilers are designed to operate at 425 lb. pressure and 725 deg. temperature. To operate continuously at full capacity each furnace requires 80,000 lb. of coal an hour.

A 90,000-sq.ft. Ingersoll-Rand condenser is included in the new installation. Condensing 700 tons of steam an hour, its tubes have a total length of nearly 80 miles.

Gantt Medal to Be Awarded at Memorial Dinner

A dinner in honor of Henry Laurence Gantt will be given by the Institute of Management at the Hotel Astor, New York City, on Nov. 19. Institution of the Gantt Memorial Medal and presentation of the first medal to Margaret Gantt Tabor will be made. Walter N. Polakov, consulting engineer, will present to the institute the deed of gift of the Gantt memorial medal fund, which will be accepted by Leon P. Alford. Addresses by Fred J. Miller and R. A. Wentworth will deal with the life, work, philosophy and significance of Henry Laurence Gantt as a management engineer and industrial leader.

John W. Lieb, Edison Pioneer, Dies After Long Illness

John W. Lieb, senior vice-president of the New York Edison Company, died Nov. 1 at the age of 69 at his home in New Rochelle, N. Y. He had been suffering for several months from an intestinal disease.

Born in Newark, N. J., Mr. Lieb was graduated from Stevens Institute of Technology in 1880, immediately after becoming a draftsman for the Brush Electric Company in Cleveland. The following year saw him in New York doing the same work for the Edison Electric Light Company, where he worked on the plans for the electrical

John W. Lieb

equipment of the Pearl Street station, the pioneer central plant for the underground distribution of light and power. Following the erection of the station he worked with Mr. Edison in subsequent tests of its use and in the inauguration of its service. On Sept. 4, 1882, he was appointed the first electrician of the company.

The next year Mr. Edison chose him to go to Milan, Italy, and there erect the dynamos and other mechanical equipment of the Edison Underground System for the Italian Edison Company. Later he installed the trolley system in Milan. His services to Italy were recognized by his decoration as Knight Commander of the Royal Order of the Crown and later promotion to Grand Officer.

Returning to the United States in 1894, Mr. Lieb advanced steadily in the Edison electric lighting organization to the post of general manager and vice-president of the New York Edison Company. He also was made president of the Electric Testing Laboratories.

Light's Golden Jubilee, which was recently celebrated, was first formally suggested on Edison's 82nd birthday, Feb. 11, 1929, when, at a luncheon of the Edison Pioneers, Mr. Lieb, tentatively outlined plans for the celebration and the Pioneers approved a resolution authorizing the appointment of a committee to propose to the electrical industry the sponsoring of the celebration.

A past president of the Edison Pioneers, of the American Institute of Electrical Engineers and of the National Electric Light Association, Mr. Lieb also belonged to many scientific societies and to civic associations. For many years he had made a study of the manuscripts of Leonardo da Vinci, investigating and translating sketches and texts in connection with his researches and observations, particularly those in the field of natural science and engineering. He owned the largest library relating to da Vinci in America.

Mr. Lieb received the Edison Medal of the American Institute of Electrical Engineers for his work in connection with the development and operation of electric control stations for illumination and power.

A.S.R.E. 25th Anniversary in New York, Dec. 4-7

The twenty-fifth anniversary of the American Society of Refrigerating Engineers, to be celebrated in New York City the first week in December, will be a high spot in the history of refrigeration, attracting the full attention of its various fields. This was the opinion expressed at the recent council meeting at the society headquarters, when the program committee outlined plans for this event.

The ceremony of the anniversary will be held on the evening of Dec. 5 in the Engineering Auditorium, and will include the induction of three men prominent in the scientific world. These men, whose names will be announced shortly, have won distinction through efforts allied to progress in this field. In honoring them, as in the honoring of John E. Starr earlier in the year, the society is distinguishing those qualities which typify the engineer as a leader and engineering profession as a leader in the world at large.

The meeting will last four days, Dec. 4 to 7, and be held at the Pennsylvania Hotel and the Engineering Societies Building, 29 West 39th St. Each session will be devoted mainly to some specific subject, and there will be a joint session with the American Society of Mechanical Engineers.

At each of the technical sessions a prominent industrialist will make the keynote address. This is a new arrangement and is intended to shed light on the present status of refrigeration in the many fields of activity and reveal something of its future possibilities.

The opening technical session will be a departure from custom. At this time attention will be drawn to the general subject of research policies in the refrigeration industries. The feature of this meeting will be the reading of the prize papers which were presented in the student research competition. The rest of the day will be devoted to reports, discussion of needed development, and several addresses to indicate the place of research in this and other allied industries.

Prize of $3,000 Offered for New Cutting Gases

To promote the use of illuminating or city gas for metal-cutting operations, prizes aggregating $3,000 have been offered by the Alexander Milburn Company, of Baltimore, Md., manufacturers of welding and cutting equipment. Three prizes of $1,000 for the years 1930-31-32 will be awarded for the best authenticated results accomplished with illuminating or byproduct gases tending to lower the costs of the present methods. A committee of engineers and the head of one of the universities have been asked to act as advisers, and to appoint judges.

The purpose of these awards, as explained in the announcement, is to encourage the use of illuminating or similar inexpensive gases in place of the more costly acetylene used as a preheating agent in torches wherein a stream of oxygen is used to cut steel and iron. Particulars concerning the methods of determining the awards will be furnished on application to the Alexander Milburn Company, 1416 West Baltimore St., Baltimore, Md.

Simplified Practices Gain Support

Acceptances to simplified practice recommendations now in effect, amount to 22,742, of which number 21,488 are from individuals and 1,254 from trade associations, according to an announcement just made public by Ray M. Hudson, assistant director of the National Bureau of Standards, Department of Commerce. His announcement is based on a review of activities for the third quarter of this year.

The number of acceptances to commercial standards now totals 1,758. During the period (July 1 to Sept. 30) for which the review is made there was a gain of 753 acceptances to simplified practice recommendations and 322 acceptances to commercial standards. Among those related to the power field are: a regional recommendation on high-volatile bituminous coal, a commercial standard for industrial fuel oils, and standards for standard weight malleable-iron and steel screwed unions, plain, three-plug and ring-gage blanks.

Coming Conventions

American Institute of Electrical Engineers. District meeting at Chicago, Ill., Dec. 2-4. Annual winter convention at New York, N. Y., Jan. 27-31, 1930. F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Society of Mechanical Engineers. Annual meeting at New York, N. Y., Dec. 2-6. Secretary, Calvin Rice, 33 West 39th St., New York City.

American Society of Refrigerating Engineers. Twenty-Fifth Anniversary Meeting at Hotel Pennsylvania, New York City, Dec. 4-7. Secretary, David L. Fiske, 37 West 39th St., New York City.

American Society of Heating & Ventilation Engineers. Annual meeting in Philadelphia, Pa., Jan. 27-30, 1930, at the Benjamin Franklin Hotel. Secretary, A. V. Hutchinson, 33 W. 39th St., New York City.

International Heating & Ventilating Exposition. Commercial Museum, Philadelphia, Pa., Jan. 27-31, 1930. Manager, C. F. Roth, Grand Central Palace, New York City.

International Congress for General Mechanics at Liege, Belgium, Aug. 31 to Sept. 7, 1930. For information address Alb. Schlag, 4 Place Saint-Lambert, Liege, Belgium.

National Electric Light Association. Annual convention at Municipal Auditorium, San Francisco, Calif., June 16-20, 1930. Secretary, A. J. Marshall, 420 Lexington Ave., New York City.

National Exposition of Power and Mechanical Engineering. Grand Central Palace, New York City, Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York City.

National Marine Engineers' Beneficial Association. Annual convention at Hotel Barlum, Detroit, Mich., the week of Feb. 10, 1930. Secretary, A. L. Jones, 9th St. and Mount Vernon Place, N. W., Washington, D. C.

OBITUARY

HARRY A. ORR, 53, of Charlotte, N. C., long prominent in the electric power industry, died Oct. 26 at Anderson, S. C. Following his graduation in electrical engineering at Auburn Polytechnic Institute, Mr. Orr accepted a position with the General Electric Company at Pittsfield, Mass. Later he was transferred to Atlanta, Ga., serving as Southern representative.

Returning to Anderson, he became president of the Savannah River Power Company, builders of the Gregg Shoals plant. He also was vice-president of the Anderson Water, Light & Power Company, of which his father, the late Dr. S. M. Orr, was president. When his father died, he succeeded him as president and treasurer of the company, remaining in that capacity until the corporation was absorbed by the Southern Public Utilities Company, in 1913, when he was made manager of the Anderson branch. In May, 1927, he was promoted to the position of manager of the Charlotte branch, and since that time had made his home in that city.

RALPH WAINWRIGHT POPE, honorary secretary of the American Institute of Electrical Engineers since 1911, died unexpectedly of heart disease, Nov. 1, at his home in Great Barrington, Mass., where he was born. He was 85 years old. Widely known among the older generation of engineers as a pioneer in telegraphy, Mr. Pope founded and was editor of the periodical *Electrical Power*. In 1865 he was elected secretary of the A.I.E.E., and held that office until 1911, when he was made honorary secretary. He was also an honorary member of the Franklin Institute.

PERSONALS

HARVEY N. DAVIS, president of Stevens Institute of Technology, has been appointed a manager of the American Society of Mechanical Engineers to fill the unexpired term of L. B. McMillan, who was killed on Aug. 9 in an airplane accident. Robert M. Gates has been designated to take Mr. McMillan's place as council representative on the finance committee of the society and also on the executive committee of the council.

C. D. RIDDLE has been appointed general superintendent in charge of construction of the Furman Shoals project to be built for the Georgia Power Company on the Oconee River by the Dixie Construction Company. Mr. Riddle planned the construction layouts for the Jordan Dam, Upper and Lower Tallassee hydro-electric plants and the Gorgas and Mobile steam plants of the Alabama Power Company. He will have as assistants Frank Smith, H. S. Davis and A. T. Beauregard, all engineers of the Dixie company.

EDWARD B. NEWILL has resigned as manager of the control engineering department of the Westinghouse Electric & Manufacturing Company to become associated in an executive capacity with the radio manufacturing company being formed jointly by the General Motors Corporation and the Radio Corporation of America. Mr. Newill entered upon his new position Oct. 16, under the title of assistant to the president of Delco Products Company, at Dayton, Ohio.

G. L. KOTHNY, executive engineer and director of the C. H. Wheeler Manufacturing Company, has resigned to accept the position of vice-president and general manager of the Sperry Sun Well Surveying Company. Mr. Kothny is widely known for the introduction of the steam jet air ejector for use in power and industrial plants. He is a co-inventor of the Radojet air pump, in recognition of which he was awarded the Longstreth Medal of Merit by the Franklin Institute.

ROBERT A. MONROE, assistant chief of the civil engineering division of the Pacific Gas & Electric Company, San Francisco, has resigned and left California on Nov. 1 to accept a position in the hydraulic department of the Aluminum Company of America, at Pittsburgh, Pa.

CHARLES LE GEYT FORTESCUE, chief consulting transmission engineer for the Westinghouse Electric & Manufacturing Company, was recently awarded an honorary degree of Doctor of Laws by Queens University in recognition of his outstanding work in the field of electrical-transmission engineering.

Business Notes

Consolidation Coal Company, New York City, announces that R. C. Gilbert, formerly manager at the Detroit office has been appointed manager of the Cleveland office to replace A. G. Olson, who has been appointed manager of the Detroit office. E. C. Payne, formerly western service manager, is now manager of the New York sales office, replacing J. F. Carney who, after many years of service with the company, has resigned. H. A. Damcke, formerly eastern sales manager, has resigned to engage in other business, and the title has been discontinued.

Dampney Company of America, Hyde Park, Boston, Mass., has opened a direct factory branch office in the Bourse Building, Philadelphia, Pa. C. J. Hunter will continue as branch manager.

Cutler-Hammer, Inc., Milwaukee, Wis., announces, with the removal of its St. Louis district sales office from 611 Olive St. to 1914 Washington Ave., the establishment of a warehouse where large stocks of its products will be kept on hand. The new warehouse covers almost 4,000 sq.ft. of floor space.

Wagner Electric Corporation, St. Louis, Mo., announces that D. O. Reardon is now representing the company in 64 counties in Iowa, with headquarters at Des Moines. Mr. Reardon was formerly Iowa representative for the merchandising division of the Westinghouse Electric & Manufacturing Company.

Jefferson Electric Company, Chicago, Ill., has won its suit against the Great Western Fuse Company of Pittsburgh for infringement of its patent on a renewable fuse. The Great Western company was declared in contempt of an injunction issued Nov. 20, 1928, upholding the Jefferson company's patent.

Trade Catalogs

Pumps—Bulletin No. 61 describing American-Marsh Type HL-Low Head and Type HS-High Head ball-bearing centrifugal pumps for general service has been recently published by the American Steam Pump Company of Battle Creek, Mich. Besides illustrations of the pumps, the 12-page booklet also contains general data and characteristic curves for both types.

Piping—"Report of Tests on 1,350-lb. Piping Materials" is the title of a new bulletin prepared by the National Valve & Manufacturing Company, 3101 Liberty Ave., Pittsburgh, Pa., from data obtained in steam and hydraulic tests on high-pressure piping materials as recommended for this service by the recent tentative American standard. Results of these tests, which covered a period of several weeks, should be of interest to all those using pressures of 250 lb. and higher.

Regulators—Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., has just issued a comprehensive catalog of industrial regulators. Well-illustrated, this catalog comprises a group of bulletins classified under three main headings: industrial motor valves; temperature, pressure and combustion controllers; automatic control of unit heaters. Included in the publication are valuable data and diagrams of industrial applications.

Meters—The Bailey Meter Company, of Cleveland, Ohio, is now distributing two new bulletins. The first, No. 12, briefly describes all products of the company, listing boiler meters, multi-point gages, fluid meters, temperature and pressure recorders, feed-water regulators, reducing valves and pump governors, among others. The second, No. 110, gives data on Selsyn operated devices for remote indication and record of liquid level, flow, pressure, temperature, draft, position and other factors in the operation of all types of power plants.

With the Society Sections

A. S. M. E., Boston Section. Meeting Nov. 13, Engineers' Club at 7:45 p.m. Subject: "Lubrication," by Prof. A. E. Norton, Harvard Engineering School. Professor Norton has been doing research work on the subject and has much valuable data. Motion pictures will also be shown.

A. S. M. E., Bridgeport Section. Meeting Nov. 14, University Club, Golden Hill St., Bridgeport, Conn. at 8:15 p.m. Subject: "Refrigeration Practice of Today," by R. H. Greene, past-president of the American Society of Refrigerating Engineers. Ernest Hartford assistant secretary of the A. S. M. E., will discuss the matter of licensing engineers.

A. S. M. E., Metropolitan Section. Power meeting, Nov. 21, Engineering Societies Building, Room 501, at 8:00 p.m. Subject: "Experiences in Chlorinating Condenser Circulating Water," by V. M. Frost, assistant to general superintendent of generation, and W. F. Rippe, test engineer at Kearny, both of the Public Service Electric & Gas Company, Newark, N. J.

A. S. H. & V. E., Boston Chapter. Meeting, Dec. 9. Subject: "Recent Development in the Control of Direct Steam Heating," by Webster Tallmadge, steam specialist, of New York City.

A. S. H. & V. E., Philadelphia Chapter. Meeting, Nov. 14, Fidelity-Philadelphia Trust Bldg., at 7:30 p.m. Subject: "Invisible Service in Office Building Management," by John B. Lear and C. R. Cheyney, Fidelity-Philadelphia Trust Company. Inspection of the building will follow the meeting.

A. I. E. E., New York Section. Power Group Meeting, Dec. 9, Engineering Societies Building at 7:30 p.m. Subject: "Power System Connections."

National Research Council. Committee on electrical insulation of the Division of Engineering and Industrial Research will hold annual meeting at Massachusetts Institute of Technology, Cambridge, Mass., Nov. 14-16.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.10 @ $2.45
Kanawha	Columbus	1.30 @ 1.60
Smokeless	Cincinnati	2.25 @ 2.50
Smokeless	Chicago	2.10 @ 2.25
S. E. Kentucky	Chicago	1.30 @ 1.60
Steam	Pittsburgh	1.40 @ 1.75
Gas Slack	Pittsburgh	1.00 @ 1.10
Big Seam	Birmingham	1.50 @ 1.75
Anthracite (Gross Tons)		
Buckwheat	New York	$2.65@ 2.75
Barley	New York	1.40@ 1.50

FUEL OIL

New York—Nov. 7, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6c. per gal.

St. Louis—Oct. 30, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.596 per bbl. or 42 gal.; 26@28 deg., $1.646 per bbl.; 28@30 deg., $1.696 per bbl.; 30@32 deg., $1.746 per bbl.; 32@36 deg., gas oil, 5.023c. per gal.; 37@40 deg., distillate, 5.98c.

Pittsburgh—Nov. 5, f.o.b. local refinery, 30@34 deg., fuel oil, 4.87½c. per gal.; 36@40 deg., 5.12½c. per gal.

Philadelphia—Nov. 1, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 22 deg. plus, $1.575@$1.625 per bbl.; 23@27 deg., $2.10@$2.15 per bbl.

Cincinnati—Oct. 29, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5.25c. per gal.; 26@30 deg., 5.5c. per gal.; 30@32 deg., 5.75c. per gal.

Chicago—Nov. 1, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 80@85c. per bbl.; 26@30 deg., 95c.@$1.00 per bbl.; 30@32 deg., $1.20 per bbl.

Boston—Nov. 4, tank-car lots, f.o.b., 12@14 deg., Baume 4.25c. per gal.; 28@32 deg., 5.6c. per gal.

Dallas—Nov. 2, f.o.b. local refinery 26@30 deg., $1.30 per bbl. or 42 gallons.

New Plant Construction

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Conn., Stamford—Fairfield County Ice Co., awarded contract for the construction of an 80 x 222 ft. ice plant to Sullivan & Tymon, Atlantic St. Estimated cost $125,000.

Fla., Lake Worth—East Coast Refrigeration Co., D. C. Smith, Secy., plans the construction of a 2 story, 65 x 120 ft. refrigeration plant for handling perishable produce. Estimated cost $80,000.

Ill., Chicago—Wallach Bros., 134 North La Salle St., will receive bids about Nov. 20 for a 9 story apartment building including mechanical refrigeration system, etc. at 1330 South Michigan Ave. Estimated cost $1,700,000. M. L. Bein & Co., 100 North La Salle St., are architects.

Ind., Evansville—Bd. of Water Works, will readvertise for new bids for waterworks improvements including pumping station, etc. Estimated cost $18,000. Former bids rejected.

Ind., Knightown—Indiana Soldiers & Sailors Orphans Home, L. A. Cortner, Supt., will receive until Dec. 10, for the construction of a group of buildings including power plant, equipment, etc. Estimated cost $200,000.

Kan., Junction City—City defeated bond election for $425,000 for the construction of a municipal electric light and power plant.

Mass., Allston (Boston P. O.)—Gold Brand Confectionery Co., 76 Beverly St., Boston, is receiving bids for the construction of a boiler room with loading platform at 42 Everett St., here. Estimated cost $40,000. Krokyn & Browne, 120 Milk St., Boston, are architects.

Mass., Boston—New England Medical Center, J. A. Cousen, Pres., Tufts College, had preliminary plans prepared for the construction of Tufts teaching clinic, nurses home and laboratory to include power plant at Bennet and Ash Sts. Andrews, Jones, Biscoe & Whittemore, 50 Congress St., are architects. A. Kellogg, 585 Boylston St., is engineer.

Mass., Dorchester (Boston P. O.) Edison Electric Illuminating Co., 70 State St., Boston, awarded contract for the construction of a 1 story addition to power sub-station on Hoyt St. to J. F. Fitzgerald Construction Co., 38 Chauncey St., Boston. Estimated cost $40,000.

Mass., East Boston (Boston P. O.)—Boston Ice Co., 11 Deerfield St., Boston, is having preliminary plans prepared for the construction of an ice plant on East Eagle St. here. Private plans.

Mass., Somerville (Boston P. O.)—Rubel Ice Corp., c/o A. W. K. Billings, Jr. Inc., Little Bldg., Boston, Archt., awarded contract for a 75 x 135 and 250 x 334 ft. ice plant on Bleachery Court to A. Rotelli, 681 Broadway, Providence, R. I. Estimated cost $100,000.

Mich., Detroit—Detroit & Canada Tunnel Co., 527 Majestic Bldg., awarded contract for the construction of a 1 and 4 story, 50 x 89 ft. ventilation building for vehicular tunnel under Detroit River to Gallagher & Fleming, 6500 Epworth Blvd., here. Estimated cost $150,000.

Mich., Detroit—Union League Club, J. A. King, Executive Secy., 35 West Grand River Ave., awarded contract for an 11 story club building on West Fort St. to Walbridge Aldinger Co., Penobscot Bldg. Estimated cost $1,000,000. Steam heating and ventilation systems, boilers, elevators, etc. will be installed.

Mo., St. Louis—Builders Investment Co., E. W. Banister, Pres., Paul Brown Bldg., awarded contract for the construction of a 35 story office building at 12th Blvd. and Olive to Pine Sts. to B. W. Construction Co., 720 Cass St., Chicago, Ill. Estimated cost $5,500,000.

Neb., Lincoln—City is having plans prepared for extensions and improvements to electric light plant. Burns & McDonnell Engineering Co., 401 Interstate Bldg., Kansas City, Mo., is engineer.

N. J., Jersey City—Spingarn Realty Co., 591 Summit Ave., is having plans prepared for the construction of a 15 story office building including steam heating and ventilation systems, boilers, elevators, etc. at Oakland and Newark Aves. Estimated cost $500,000. W. Neumann, 40 Journal Sq., is architect.

N. Y., Ithaca—Cornell University has made appropriation for addition to heating plant. Estimated cost $180,000. No contracts have been awarded. This corrects report published in Nov. 5 issue.

O., Steubenville—Ohio Power Co., F. Howard, Asst. Gen. Mgr., 301 Cleveland Ave., Canton, will soon award contract for the construction of a sub-station on Stanton St. here.

Pa., Philadelphia — American Ice Co., 121 North Broad St., awarded contract for the construction of a 143 x 148 ft. ice plant at Limekiln Pike and 18th St. to Sutton & Stephenson, 1307 Washington Ave.

Pa., Pittsburgh—University of Pittsburgh, J. C. Bowman, Chancellor, Bigelow and Parkman Sts., plans a clinic and dispensary at 5th and Lathrop Sts. Estimated cost $750,000. E. P. Mellon, Oliver Bldg., is architect. Stone & Webster, supervising engineers, will build and award separate contracts. Taking bids on excavation, foundation and fabricating steel.

Pa., Pittsburgh — Westinghouse Electric & Mfg. Co., East Pittsburgh, is having plans prepared for the construction of an 11 story central engineering laboratory. Estimated cost $300,000. B. H. Prack, Martin Bldg., N. S., Pittsburgh, is architect.

Tenn., Jackson—City voted $750,000 bonds for extensions and improvements to light plant. Burns & McDonnell Engineering Co., 401 Interstate Bldg., Kansas City, Mo., is engineer.

Tex., Bakerfield—C. William, Fort Stockton, plans the construction of a 20 to 25 ton ice plant here. Estimated cost $30,000.

Tex., Brownsville — Cameron County Water Improvement Dist. No. 13, awarded contract for irrigation project including pumping unit, etc., to J. D. George Construction Co., Donna. Estimated cost $280,000.

Tex., Harlingen—Cameron Co. Water Improvement Dist. No. 15, c/o A. Houghton, Secy., voted $199,000 bonds for irrigation project including pumping plant and distribution system, etc.

Tex., Lamesa — City awarded contract for waterworks extensions including pumping equipment, etc., to Vedder Construction Co., Sweetwater. $57,000.

Tex., Port Arthur — City plans bond election Nov. 26 to vote $60,000 bonds for waterworks improvements including pumping equipment, mains, etc.

Tex., San Benito—Central Power & Light Co., c/o F. C. Ludden, Dist. Mgr., will soon award contract for the construction of a 54 x 70 ft. cold storage plant. Private plans.

Wash., Seattle — United Medical & Dental Building, Inc., will soon receive bids for the construction of a 16 story addition to office building at 5th St. and Olive Way. Estimated cost $1,100,000. J. Graham, Dexter Horton Bldg., is architect.

Wis., Delafield—Milwaukee Electric Railway & Light Co., 215 Sycamore St., Milwaukee, will soon award contract for the construction of a 62 x 109 ft. power house here. F. Luber, c/o owner, is architect.

Equipment Wanted

Boiler, Refrigeration System, etc. — Gratersford, Pa. — Day & Zimmerman Engineering & Construction Co., 112 North Broad St., Philadelphia, will receive bids until Nov. 15, for a new or used 50 hp. 100 lb. pressure tubular boiler, also refrigeration system, etc., for Eastern Penitentiary, here.

Ice Arena Equipment—Meaford, Ont.—Curling Club, C. E. Brown, Pres., interested prices complete equipment for proposed artificial ice arena.

Generator and Condenser—Spencer, Ia.—City, c/o E. Penning, Clk., plans to purchase generator and condenser.

Motors—Crystal Springs, Miss.—City, W. L. Gallman, Supt., prices on electric motors and transmission machinery, etc.

Pumps, etc. — Tranquillity, Calif. — Tranquillity Irrigation Dist., deep well turbine pumps, etc. for proposed irrigation project.

Transformers, Switches, Etc.—Columbus, O.—Bd. of Purchases, City Hall, will receive bids until Nov. 21 for combination disconnecting pothead and individual lamp transformers, 30 kva. subway moving coil, oil cooled type constant current regulator, remote control oil contactor switch, etc.

Turbine, Electric Generator, etc.—Salt Lake City, Utah—University of Utah, T. Hull, Secy., will receive bids until Nov. 25 for water-driven turbine, electric generator and auxiliary apparatus for proposed addition to hydraulic laboratory at University and First South Sts.

Turbine, Pumps, Motors, Etc.—Park Rapids, Minn.—Village, c/o W. Langguth, Recorder, will receive bids until Nov. 19 for 20,000 hp. deep well turbine or plunger pumps and motors, etc. for proposed waterworks improvements.

Industrial Projects

Calif., Los Angeles—Western Light & Fixture Co., 301 South Los Angeles St., awarded contract for a 1 story, 160 x 198 ft. factory at Third and Gary Sts. to W. P. Neil Co. Inc., 4828 Lomita Vista Ave. Estimated cost $40,000.

Calif., San Carlos—General Electric Co., acquired a site and plans the construction of a factory and distribution plant.

Conn., East Hartford (br. Hartford)—Chance Vought Corp., Long Island City, N. Y., awarded contract for the construction of a 1 story, 350 x 675 ft. airplane factory here to R. G. Bent Co., 93 Edwards St., Hartford. Estimated cost $1,000,000.

Conn., Stamford—Electric Specialty Co., 211 South St., had plans prepared for the construction of a 2 story, 45 x 145 ft. factory. Estimated cost $60,000. Private plans.

Mass., South Dartmouth (br. New Bedford)—E. H. R. Green, Round Hill St., awarded contract for the construction of a 1 story, 100 x 120 ft. aircraft factory and 100 x 175 ft. hangar building at Round Hills Aviation field to Austin Co., 1612 Euclid Ave. E., Cleveland, O. Estimated cost $200,000.

Mich., Detroit—Detroit Die Casting Co., 284 Iron St., plans the construction of a 1 and 2 story, 100 x 240 ft. factory at Oakman Blvd. Estimated cost $75,000. Private plans. Electric motors and equipment for die casting shop will be required.

Mich., Detroit—Mitchell & Smith, Copeland Ave., awarded contract for the construction of a 1 story, 80 x 170 and 25 x 50 ft. cork products factory to Austin Co., General Motors Bldg. Estimated cost $75,000. Electric motors and grinding equipment for grinding cork and leather will be required.

Mich., Detroit — Kelsey Wheel Co., 3600 Military Ave., is receiving bids for a 1 story, 135 x 320 ft. addition to factory. Estimated cost $100,000. A. Kahn, Marquette Bldg. is architect. Electric motors and equipment for the manufacture of automobile wheels will be required.

Mich., Detroit—Wood Hydraulic Hoist & Body Co., 2924 Riopelle St., awarded contract for the design and construction of a 1 story, 80 x 190 and 50 x 130 ft. factory to O. Randolph, Inc., West Jackson Blvd., Chicago, Ill. Estimated cost $75,000.

Mich., Lansing—Olds Motor Works, 1101 Division St., awarded contract for a 2 story, 75 x 140 ft. addition to motor car factory to Owen-Ames-Kimball Co., 38 Pearl St, N. W., Grand Rapids. Estimated cost $75,000. Electric motors and conveyor system and equipment will be required.

N. J., Bloomfield—Westinghouse Lamp Co., Chamber of Commerce Bldg., Pittsburgh, Pa., awarded contract for the construction of a 5 story wire products factory to White Construction Co., Inc., 95 Madison Ave., New York, N. Y. $700,000. Also having sketches made for the construction of a 2 story electric manufacturing plant at State Highway and Haynes Ave., Newark. Estimated cost $150,000. J. H. and W. C. Ely, 605 Broad St., Newark, are architects.

O., Cleveland—Wheeler Metal Products Co., E. F. Haflinger, Treas., 1637 Collamere Rd., plans the construction of a 1 story, 80 x 300 ft. factory. Estimated cost $150,000. Austin Co., 16112 Euclid Ave., is architect.

Pa., Philadelphia—Pattush Bros., Water and Wolf St., will soon receive bids for the construction of a 2 story, 115 x 250 and 45 x 200 ft. factory at Swanson and Oregon Sts. H. H. Kline, 709 Chestnut St., is architect. Pennsylvania Metal Co., 25th and Wharton Sts., is lessee.

Wis., Milwaukee—Pittsburgh Plate Glass Co., 205 Pittsburgh Ave., is having preliminary plans prepared for the construction of a 5 story paint factory on Barclay St. Estimated cost $1,000,000. Private plans.

Va., Newport News—H. E. Dodge Corp., is having plans prepared for the construction of a group of 1 story factory buildings. Estimated cost $1,000,000. P. L. Small & Associates, Terminal Tower, Cleveland, O., are architects.

B. C., Vancouver—Western Bridge Co. Ltd., J. A. McFarlane, Engr. and Gen. Mgr., Columbia and First Ave., is having plans prepared for addition to structural steel and bridge fabricating shops at False Creek. Estimated cost $400,000. Private plans.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

LOWERED discounts on switches, fuses and cable indicate firmness in electrical supplies, compared with October prices. The rise in linseed oil, which featured last month's market, is now reflected in higher prices for white lead in oil—up ½c., to 14¼c. per lb., New York. Wiping material, except white waste, tends downward very slightly. Genuine, highest grade babbitt metal is off 6c., to 58c. per lb., delivered, New York.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		(net) 60c. per ft.
Common, 2½-in., cotton, rubber-lined, 80c. per ft., list, less		50%

Air—Best grade

¾-in., per ft	3-ply	$0.30	4 ply	$0.36

Steam—Discounts from List

First grade....40%	Second grade.....45%	Third grade....50-10%	

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	60%

LEATHER BELTING—List price, 24c. per lin.ft., per inch of width, for single ply, at New York warehouses:

Grade	Discount from list
Medium	30-10%
Heavy	30%

RAWHIDE LACING—For cut, best grade, 30-5%; 2nd grade, 45-5%. For laces in sides, best, 57c. per sq.ft.; 2nd, 52c., net. Semi-tanned, cut, 30-5%.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.75
Duck and rubber for piston packing	.90
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.85
Wire insertion asbestos sheet	1.20
Rubber sheet	.45
Rubber sheet, wire insertion	.75
Rubber sheet, duck insertion	.55
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts from list at New York warehouses are as follows:

85% magnesia, high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.10 per bbl., without bags, delivered by truck to site of job. Bag charge, 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, beams and channels, 3 to 15-in.; angles, 3 to 6-in., ¼-in. thick; tees, 3-in. and larger; and plates, ¼-in. thick and heavier; all $3.30 per 100 lb. in lots up to 3,999 lb.

COTTON WASTE—The following prices are in cents per lb., at warehouse:

	New York	Cleveland	Chicago
White	13.00	16.00	15.00
Colored	9.50	12.00	12.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed white wipers, as follows:

Chicago (100 lb. bales)	$0.16
New York (100 lb. bales)	.12½
Cleveland (per thousand)	38.00

LINSEED OIL—These prices are for raw oil in barrels, f.o.b., in 1 to 4 bbl. lots:

	New York	Cleveland	Chicago
Per pound	$0.161	.....	$0.165

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b., New York:

	Dry	In Oil
Red	$13.75	$15.25
White	13.75	14.25

RIVETS—The following quotations apply on fair-sized orders from warehouse:

Tank rivets, $\frac{7}{16}$-in. diameter and smaller, list (Apr. 1, 1927) less 60% in full packages, for immediate delivery from warehouse stocks in New York and vicinity.

Structural rivets, ½-in., round head, per 100 lb.:

New York	$4.50*
Chicago	4.00
Pittsburgh mill	3.10

*Price is for full kegs; broken-keg lots are $6.00 net, delivered.

REFRACTORIES—Prices in car-loads, f.o.b. plant:

Chrome brick, eastern shipping points	per net ton	$45.00
Chrome cement, 40@50%, Cr_2O_3, in bulk	per net ton	22@25
Chrome cement, 40@50%, Cr_2O_3, in sacks	per net ton	26@29
Magnesite brick, 9-in. straights	per net ton	65.00
Magnesite brick, 9-in. arches, wedges and keys	per net ton	71.50
Magnesite brick, soaps and splits	per net ton	91.00
Silica brick, Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9-in. shapes, Pennsylvania	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	35@38
Chrome ore crude, 40@50%	per net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	58.00
Commercial genuine, intermediate grade	43.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	12.00

COLD DRAWN STEEL—Shafting and screw stock, warehouse prices per 100 lb., base, are as follows:

	New York	Cleveland	Chicago
Round or hexagon	$3.60	$3.65	$3.60
Flat or square	4.10	4.15	4.10

BOILER FITTINGS—F.o.b. warehouse, Jersey City, N. J., discounts from list:

Copper ferrules	70%
Boiler flanges	65–5%
Boiler stay bolts	60%
Boiler patch bolts	20%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following basing discounts from list are for large mill lots at Pittsburgh mill:

BUTT WELD

Steel Inches	Black	Galv.	Iron Inches	Black	Galv.
1 to 3	62%	50½%	1 and 1¼	31%	15%

LAP WELD

2	55%	43½%	2	23%	9%
2½ to 6	59%	47½%	2½ to 3½	28%	13%
7 and 8	56%	43½%	4 to 6	30%	17%
9 and 10	54%	41½%	7 and 8	29%	16%
11 and 12	53%	40½%	9 to 12	26%	11%

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1¼	60%	49½%	1 to 2	34%	18%
2 to 3	61%	50½%			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53%	42½%	2	29%	13%
2½ to 4	57%	46½%	2½ to 4	34%	20%
4½ to 6	56%	45½%	4½ to 6	33%	19%
7 and 8	52%	39½%	7 and 8	31%	17%
9 and 10	45%	32½%	9 to 12	21%	8%
11 and 12	44%	31½%			

BOILER TUBES—Following are net prices per 100 ft. at New York warehouses on tubes manufactured according to specifications of the American Society of Mehanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17.07
1¼	.....	.....	19.20
1½	.....	$38.00	17.92
1¾	.....	28.50	20.48
2	$17.33	25.00	20.24
2¼	19.84	28.25	23.00
2½	21.60	34.00	26.03
3	25.50	42.50	27.04
3¼	30.25	49.50	30.67
3½	31.50	52.75	33.33
4	38.03	67.00	40.11

These prices are net, per 100 ft., based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

2 in. and smaller	5c. per cut.	3 in.....	9c. per cut.
2¼ and 2½ in.....	6c. per cut.	3¼ to 4 in...	10c. per cut.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft., New-Style, A.B.C., with fibre bushing:

B. & S. Size	BX Two Cond. M. Ft.	BX Three Cond. M. Ft.	Lead Two Cond. M. Ft.	Lead Three Cond. M. Ft.
No. 14 solid....	$33.85 (net)	$48.00 (net)	$180.00	$220.00
No. 12 solid....	136.00	180.00	225.00	275.00
No. 10 solid....	185.00	235.00	275.00	325.00
No. 8 stranded..	305.00	375.00	420.00	500.00
No. 6 stranded..	440.00	530.00	615.00	.....

From the above lists discounts are:	BX	Lead Covered
Less than coil lots	50%	30%
Coils to 1,000 ft	60%	34%
1,000 to 5,000 ft	63%	36%
5,000 ft. and over	65%	48%

CONDUIT—Price per 1,000 ft.; **ELBOWS AND COUPLINGS,** per 100 pieces, extra f.o.b. New York warehouse. Discount of 5 per cent. for payment in 10 days. No delivery charges, regardless of quantity.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
¾	72.07	78.63	10.21	11.63	6.46	7.03
1	103.31	113.00	15.10	17.21	8.39	9.13
1¼	139.77	152.88	20.51	23.07	11.78	12.75
1½	167.12	182.79	27.34	30.76	14.56	15.75
2	224.85	245.94	50.13	56.40	19.41	21.01
2½	355.50	388.85	82.03	92.28	27.73	30.01
3	464.88	508.50	218.74	246.10	41.59	45.01
3½	585.30	637.74	483.04	543.46	55.46	60.02
4	714.17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less Than $10 List	$10 List to $100	$100 List and Over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices, each, in standard-package quantities:

CUT-OUTS, PLUG, SOLID, NEUTRAL OR 2-FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID, NEUTRAL OR 2-FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$21.50
No. 16 cotton reinforced heavy		25.00
No. 18 cotton reinforced light		15.50
No. 16 cotton reinforced light		22.00
No. 18 cotton Canvasite cord		17.00
No. 16 cotton Canvasite cord		27.00
No. 16 super service cord or similar (2 wire) in 1,000 ft.	$70.80	*76.70
No. 14 super service cord or similar (2 wire) in 1,000 ft.	106.20	*115.05

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List Each
3-amp. to 30-amp.,	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less than one-fifth standard package, 60%; one-fifth to standard package, 65%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Cartony Quantit
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken cartons	Net list
Unbroken cartons	17%
Ten unbroken cartons	34%
Discount Without Contract—Renewals:	
Broken cartons	Net list
Unbroken cartons	17%
Ten unbroken cartons	34%
Discount With Contract—Fuses:	
Broken cartons	5%
Unbroken cartons	20%
Ten unbroken cartons	36%
Discount With Contract—Renewals:	
Broken cartons	Net list
Ten unbroken cartons	36%

Carton quantities may be combined to obtain maximum discounts.

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500), per 100	$2.80
0–30 ampere, less than standard package, per 100	3.10

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard, A type bulbs:

100—130 Volt Watts	General Type	Price Each	200—260 Volt Watts	Special Type	Price Each
15	A 17	$0.20	25	A 19	$0.25
25	A 19	.20	50	A 21	.25
40	A 21	.20	100	A 23	.45
50	A 21	.20	...	.....	.....
60	A 21	.20	...	.....	.....
100	A 23	.35	...	.....	.....

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net, allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain, separable, attachment plug	$0.18
Composition, 2-piece, attachment plug	.27
Swivel attachment plug	.12
Small size, 2-piece plug, composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f.o.b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$6.50	$8.90	$11.20	$19.00
12	9.90	11.40	14.00	25.00
10	13.50	15.40	18.50	33.50
8	19.90	22.50	25.00	47.50
6	.....	.....	36.00	.....
4	.....	.....	52.00	.....
2	.....	.....	72.00	.....
1	.....	.....	97.00	.....
0	.....	.....	119.00	.....
00	.....	.....	143.00	.....
000	.....	.....	176.00	.....
0000	.....	.....	215.00	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	⅜ In. Cap Key	⅜ In. Cap Keyless	⅜ In. Cap Pull
Standard package	$0.12	$0.10	$0.16	$0.16½	$0.14	$0.20
Unbroken carton	.14	.12	.18	.18	.16	.21
Broken carton	.16	.14	.20	.20	.18	.24

WIRING SUPPLIES—

Friction tape, ¾ in., in less than 100 lb., 31c. per lb.; in 100 lb. lots, 29c. per lb.	
Rubber tape, ¾ in., in less than 100 lb., 33c. per lb.; in 100 lb. lots, 31c. per lb.	
Wire solder, in less than 100 lb., 33c. per lb.; in 100 lb. lots, 31c. per lb.	
Soldering paste, 2 oz. cans	$1.10 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$3.50	$5.70	$9.00
60	9.00	11.00	14.00
100	14.00	17.00	29.00
200	22.00	29.00	48.00

Discounts:	
Standard package	40%
Less than standard package	35%